CDM Smith

Memorandum

Working Draft

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Subject: *Remedial Technologies Screening*

U.S. Environmental Protection Agency (EPA) Remedial Investigation/Feasibility Study (RI/FS) guidance calls for the screening of remedial technologies based on effectiveness, implementability, and cost. CDM Smith conducted a summary-level evaluation of remedial technologies focusing primarily on effectiveness and implementability since these are expected to be the key factors in determining which technologies are most favorable for application at the Portland Harbor Superfund Site (Portland Harbor site). This summary-level evaluation was conducted to facilitate discussions among interested parties for the Portland Harbor site.

In accordance with EPA's RI/FS Guidance (USEPA 1988), general response actions were developed for contaminated sediments that may be expected to achieve the remedial action objectives for the site if applied as standalone response actions or in combination with one another. General response actions selected for the Portland Harbor site include:

- No Action
- Institutional Controls
- Monitored Natural Recovery
- Enhanced Monitored Natural Recovery
- Containment in Place
- In-Situ Treatment
- Removal
- On-Site Disposal (in conjunction with removal)
- Off-Site Disposal (in conjunction with removal)
- Ex-Situ Treatment (in conjunction with removal)

Based on discussions between the Lower Willamette Group and EPA, remedial technologies were identified and screened for each general response action, and documented in the draft Portland Harbor FS (Anchor QEA 2012). **Table 1** summarizes the general response actions, remedial technologies, and process options considered for evaluation in the draft Portland Harbor FS. In the following sections, process options were further evaluated to identify the site-specific conditions that may favor one representative process option over another. Although "No Action" is identified in **Table 1**, it was retained as a regulatory requirement for comparative purposes only and is not discussed further. A separate technical memorandum will be submitted at a later date providing details on the rationale for elimination and retention of the various remedial technologies and process options.

Monitored Natural Recovery

Monitored natural recovery (MNR) is defined in EPA's Sediment Remediation Guidance (USEPA 2005) as: "ongoing, naturally occurring processes to contain, destroy, or reduce the bioavailability or toxicity of contaminants in sediment." The National Research Council (NRC) defines MNR as a remedy that "relies on un-enhanced natural processes to protect human and environmental receptors from unacceptable exposures to contaminants" (NRC 2000). At the Portland Harbor site, the dominant natural recovery process is expected to be deposition of cleaner material over the top of more contaminated material such that contaminant concentrations in surface sediments (0 to 30 centimeters [cm]) will be reduced over time to levels protective of human health and the environment or to a background condition that represents contaminant contributions from the larger Lower Willamette River watershed.

MNR Effectiveness Evaluation

Sediment trap and suspended solid surface water data collected at the upper end of the Portland Harbor site suggest that incoming sediment concentrations are far lower than contaminated sediments at the Portland Harbor site suggesting that MNR may be effective at some locations in Portland Harbor depending on site-specific factors. Factors evaluated to identify whether MNR may be successful are considered MNR evaluation criteria. A summary of the MNR evaluation criteria are presented in **Table 2**. Site data will be evaluated against the MNR evaluation criteria and mapped to identify areas where MNR is not expected to be effective.

MNR Effectiveness Screening Criteria

Presence of Principal Threat Waste

CDM Smith evaluated principal threat waste (PTW) and Hot Spots in a technical memorandum provided in **Attachment A**. As indicated in the memorandum, the Oregon Department of Environmental Quality (ODEQ) has identified its Hazardous Substance Remedial Action Rules as an applicable or relevant and appropriate requirement (ARAR) for the Portland Harbor site. The Hazardous Substance Remedial Action Rules require identification of Hot Spots and application of the higher threshold for evaluating the reasonableness of the cost of treatment and of the cost of excavation and offsite disposal of Hot Spots in the FS. However, strict application of the ODEQ

Hot Spot requirement results in the entire Portland Harbor site being identified as a Hot Spot. As a result, Hot Spots were not considered as criteria for the evaluation of MNR.

Under CERCLA, there is an expectation that principal threat waste (PTW) should be treated to the extent practicable. With respect to MNR, the presence of PTW in the form of non-aqueous phase liquid (NAPL) source material will unacceptably limit the effectiveness of MNR; MNR should be excluded from consideration as a remedial technology in these areas. To identify areas where NAPL is likely to be present, a three phase partitioning analysis was performed to estimate the sediment concentration that would result in porewater concentrations greater than aqueous solubility for key site contaminants. Contaminants with sediment concentrations indicative of NAPL include benzo(a)pyrene, naphthalene, total dichlorodiphenyltrichloroethane (DDT), and chlorobenzene. **Figure 1** presents areas where a review of sediment boring logs, sediment concentrations, and pore water concentrations indicate that NAPL is present and where MNR is not expected to be effective.

Sediment Deposition Rate

As described above and presented in the draft FS, the concentration of chemicals of concern (COCs) in suspended sediments entering Portland Harbor is comparable to background concentrations. As a result, deposition of clean material is considered the primary recovery mechanism for MNR in Portland Harbor and the effectiveness of MNR will be dependent in large part on the rate of deposition. The evaluation of MNR assumes that MNR should be considered a potentially effective technology only if a 50% reduction in contaminant concentration in surface sediment will be achieved within 10 years. This reduction requires a minimum deposition rate of 2.5 centimeters per year (cm/year) and a 30 cm vertically mixed sediment interval. Areas exceeding the 2.5 cm/year threshold have been estimated based on empirical measures of changes in site bathymetry between 2003 and 2009. Sediment deposition rate based on empirical measurements is presented in **Figure 2**.

Sediment Grain Size

The percentage of fine-grained material can be used to identify low energy areas not subjected to high flow events on a regular basis. Fine-grained sediments are defined as sediments less than 60 microns (μm). Sediment less than 60 μm consist of silts and clays. For Portland Harbor, a 63 μm sieve size was used for grain size analysis purposes and grain sizes less than 63 μm were identified as fine-grained sediments. From a sediment transport perspective, silts and clays are considered cohesive sediments and are the class of sediments most likely to be transported as suspended sediments[1]. Areas with greater than 50% fines are considered depositional

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[1] Cohesive sediments are composed primarily of clay-sized material, which have strong interparticle forces due to their surface ionic charges. As particle size decreases, its surface area per unit volume (i.e., specific surface area) increases, and the interparticle forces, not the gravitational force, dominate the behavior of sediment. There is no clear boundary between cohesive sediment and non-cohesive sediment. The definition is usually site-specific. In general, finer sized grains are more cohesive. Sediment sizes smaller than 2 μm (clay) are generally considered cohesive sediment. Sediment of size greater than 60 μm is coarse non-cohesive sediment. Silt (2 μm - 60 μm) is considered to be between

environments where MNR is considered favorable. Percent fines based on analysis of sediment grain size are presented in **Figure 3**.

Surface to Subsurface Sediment Contaminant Concentration Ratios
In general, subsurface sediments in Portland Harbor have higher concentrations of contamination than surface sediments. Areas where surface sediment concentrations are greater than subsurface sediment concentrations suggest an ongoing source of sediment contamination and thus MNR is not expected to be effective in these areas. Surface sediment to subsurface sediment concentration ratios are presented in **Figure 4**.

Anthropogenic Effects
Evaluation of MNR should include factors that could prevent accumulated material remaining in place. These lines of evidence include anthropogenic effects such as dredging and propwash activities. Future maintenance dredge areas are considered areas where dredging or propwash induced erosion are likely to prevent the long-term accumulation of newly deposited sediments and thus are areas where MNR is unlikely to be effective. Potential future maintenance dredge areas and propwash areas are presented in **Figure 5**.

Wind and Wake Wave Susceptible Areas
Wind and vessel generated waves have the potential to erode newly deposited sediments. This line of evidence is supported by the presence of coarse-grained sediments along many nearshore areas within Portland Harbor. Due to changes in river stage during a typical year resulting from seasonal variations in river flow, the area subject to wind and vessel generated waves ranges from -0.5 to 14.8 feet Columbia River Datum (CRD). Nearshore areas within this elevation range are considered wind and wake wave susceptible areas and are not considered amenable to MNR due to wave induced erosion potential. Nearshore areas susceptible to wind and vessel generated waves is presented in **Figure 6**.

Enhanced Monitored Natural Recovery

Enhanced monitored natural recovery (EMNR) is potentially effective in areas where natural recovery is insufficient to reduce risks within an acceptable time frame primarily due to the rate of sedimentation (EPA 2005). Because the primary mechanism for natural recovery at the Portland Harbor site is deposition by clean material, EMNR is focused on acceleration of natural recovery processes through thin-layer placement. Thin-layer placement accelerates natural recovery by adding a layer of clean sediment over contaminated sediment to isolate contamination or to dilute contaminant concentrations through bioturbation of clean sediment mixed with underlying contaminants. EMNR through thin-layer placement may be further

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cohesive and non-cohesive sediment. Indeed, the cohesive properties of silt are primarily due to the existence of clay. Thus in engineering practice, silt and clay are both considered to be cohesive sediment." (emphasis added)
Source: U.S. Department of Interior, Bureau of Reclamation
http://www.usbr.gov/pmts/sediment/kb/ErosionAndSedimentation/chapters/Chapter4.pdf

enhanced through the use of carbon amendments (i.e., reactive EMNR) to provide a greater level of protection by reducing contaminant bioavailability.

EMNR Effectiveness Evaluation

The EMNR effectiveness evaluation relies on many of the same factors that are considered in the evaluation of MNR. Similar to MNR, the EMNR effectiveness evaluation assumes that deposition of clean material is the primary MNR process that needs to be enhanced. It is assumed that this enhancement will be achieved through the thin-layer placement of 15 – 30 cm of clean sand and that the sand must remain in place in order for EMNR to be effective. As a result, a prerequisite for EMNR is a stable environment that will not erode or remove sediments through current, anthropogenic effects (i.e., dredging for navigation and propwash), or wind or vessel generated waves. Because a stable sediment bed rather than a sediment deposition rate above 2.5 cm per year is the primary condition for EMNR, the sediment deposition rate criteria was adjusted from 2.5 cm/yr to +/- 2.5 cm per year and the percent fines threshold was reduced from 50% fines to 40% fines (which is the threshold utilized by the Lower Willamette Group). Sediment deposition rates are presented in **Figure 2** while sediment grain size is presented in **Figure 3**. All other evaluation criteria remain the same as MNR. The mapping exercise is expected to identify areas of the site that, while not quite suitable for MNR, are likely candidates for EMNR. A summary of the EMNR evaluation criteria are presented in **Table 3**.

In-Situ Treatment

In-situ treatment of contaminated sediments may be accomplished through biological (e.g., biodegradation and phytoremediation) or physical (e.g., solidification/stabilization and use of carbon amendments) means. At this time, the use of physical means such as amendments to reduce the bioavailability of sediment contaminants through sorption is considered the most favorable in-situ treatment technology applicable to the Portland Harbor site. Although a number of in-situ treatment materials are available, at this time, the application of carbon amendments (e.g., granular activated carbon [GAC]) is considered the most promising of in-situ treatment technologies applicable to contaminants present at the Portland Harbor site. GAC has been demonstrated to be effective for a wide range of organic compounds including polychlorinated biphenyls (PCBs), chlorinated pesticides such as 4,4'-DDT, and polycyclic aromatic hydrocarbons (PAHs).

In-Situ Treatment Evaluation Criteria

A literature review suggests that activated carbon can reduce the bioavailable fraction of PCBs, PAHs, and 4,4'- DDT as measured through porewater concentrations by 90% (Ghosh et al. 2011; Tomaszewski et al. 2008; Zimmerman et al. 2005). In-situ treatment is expected to be similarly effective for other hydrophobic organics such as chlorinated dibenzo dioxins and furans (PCDD/PCDF) but is expected to be less effective for more soluble organics (e.g., volatile organic compounds [VOCs]) or metals. A range of delivery mechanisms are available for GAC (e.g., direct application, and mixing with sand during or prior to placement). The evaluation of in-situ treatment assumes a GAC application rate of 3 – 5% GAC by weight within the biologically active zone. A summary of the in-situ treatment evaluation criteria are presented in **Table 4**.

The evaluation criteria for in-situ treatment are identical to the EMNR evaluation criteria with one significant exception – target treatment concentrations were developed based on sediment preliminary remediation goals (PRGs). In-situ treatment criteria were estimated based on an assumption of 90% effectiveness. The lowest sediment PRG was multiplied by 10 to arrive at a sediment treatment threshold. Sediment treatment thresholds were developed for PCBs (200 micrograms per kilogram [µg/kg]), total DDx (30 µg/kg) and carcinogenic PAHs as benzo(a)pyrene equivalents (BaPEq; 4,000 µg/kg). Sediment treatment thresholds for total PCBs, total DDx and BaPEq are presented in **Figure 7**.

As discussed above, the evaluation criteria for in-situ treatment are identical to the EMNR evaluation criteria except for the target treatment concentration criterion. The criteria in common with EMNR include the following:

- Sediment deposition rate of +/- 2.5 cm per year, which suggests the sediment bed is stable and amenable to in-situ treatment
- A percent fines content of greater than 40% fines suggesting that the sediment bed is relatively stable and amenable to in-situ treatment
- Areas with surface sediment concentrations higher than subsurface sediments suggesting that concentrations are increasing due to an ongoing source of contamination and in-situ treatment is not likely to be effective
- A stable environment that will not erode or remove sediments through current, anthropogenic effects (i.e., dredging for navigation and propwash), or wind or vessel generated waves

Areas that are suitable for EMNR and which meet the in-situ treatment criteria should be considered candidates for reactive EMNR (i.e., inclusion of reactive material in thin-layer placement). In addition, there are additional physical conditions at the Portland Harbor site where in-situ treatment may be favorable based on site-specific conditions. These include the presence of structures which may hinder cap placement or dredging activities, areas with high groundwater flux that may require the inclusion of in-situ amendments (i.e., GAC) to augment EMNR, and habitat areas where capping or dredging activities may result in a high degree of habitat disruption.

Capping

Capping is defined in EPA's Sediment Guidance (EPA 2005) as the placement of a subaqueous covering or cap of clean material over contaminated sediment that remains in place. Caps are typically constructed of a granular material, such as clean sand or gravel. In some cases, other elements such as geotextiles, reactive materials, armoring layers or habitat layers may be incorporated into the sediment cap design. In general, sediment caps are designed to reduce risk through the following primary functions:

- Physical isolation of the contaminated sediment sufficient to reduce exposure due to direct contact and to reduce the ability of burrowing organisms to move contaminants to the surface;
- Stabilization of contaminated sediment and erosion protection of sediment and cap, sufficient to reduce resuspension and transport to other sites; and/or;
- Chemical isolation of contaminated sediment sufficient to reduce exposure from dissolved and colloidally bound contaminants transported into the water column.

Caps may be designed with different layers to serve these primary functions or in some cases a single layer may serve multiple functions.

Capping Evaluation Criteria

If properly designed and implemented in conjunction with effective source control, capping can be applied across the Portland Harbor site. The primary limitations of capping are areas of high contaminant flux associated with advective groundwater transport, the presence of structures that may limit the ability to place capping materials, water depth requirements (e.g., current or potential future navigation areas), and soft sediment or steep slopes that complicate placement of cap materials. Areas of contamination that are not amenable to MNR, EMNR, or in-situ treatment should be evaluated for capping through a weight-of-evidence evaluation. Capping evaluation criteria to be included in a weight-of-evidence evaluation are presented in **Table 5**. The factors presented in **Table 5** help identify areas where capping is expected to be more favorable but will generally not exclude capping from consideration. For example, although water depth may limit the implementability of capping, this limitation can be overcome (although at greater cost) by removing material through dredging prior to cap placement. Generic cap designs that allow cap placement in a wide range of areas can be developed. For example, reactive caps (i.e., cap with an engineered layer incorporated within the cap design to treat material in-situ) can be used in areas with high groundwater and contaminant flux, armored caps can be placed in areas subject to wind and vessel driven waves, and habitat layers can be incorporated into the cap design to allow placement in areas with significant habitat value.

Key elements in the evaluation of capping include the presence of soft sediments (greater than 80% fines, **Figure 3**) which may necessitate special engineering considerations during cap placement; the presence of structures that may limit the ability to place capping material and/or increase the costs of capping (**Figure 8**); the presence of debris and pilings (**Figure 9**) which may need to be removed prior to cap placement thus increasing capping costs; wave, current and propwash induced erosion potential (**Figures 5**, **6**, **10**, and **11**) which may necessitate the use of armoring materials; water depth which may limit the implementability of capping due to navigation depth requirements (**Figure 11**); and habitat considerations which may increase the cost of capping to minimize impacts on benthic habitat (**Figure 12**). Areas where PTW in the form of NAPL have been identified can generally only be capped if organoclay amendments or other reactive layers are incorporated into the cap design and construction.

With regard to sediment slopes, where sediment slopes are steep (greater than 3:1) capping is generally not considered due to stability issues (**Figure 13**). Areas where the sediment bed slopes between 7:1 and 3:1 can be capped with special engineering considerations. Information regarding liquefaction potential, slope stability, and sediment shear strength will be required to properly design sediment caps on slopes greater than 7:1. Sediment bed slopes less than 7:1 will not require any special considerations.

Removal through Dredging or Excavation

Removal of contaminated sediment through dredging or excavation is a common method of remediating contaminated sediment. Dredging is defined as the removal of sediment under a standing column of water through mechanical or hydraulic means. Mechanical dredging removes sediment through the direct application of mechanical force to dislodge/grind/shear the material to be dredged while hydraulic dredging methods remove sediment by fluidizing it and pumping it either up to the water surface or to the handling/dewatering/disposal location. Excavation refers to sediment removal conducted after the water column above has been removed by dewatering it in an enclosure. Dredging and excavation are the two most common means of removing contaminated sediment from a water body, either while it is submerged (dredging) or after water has been diverted or drained (excavation). Both methods typically necessitate transporting the sediment to a location for treatment and/or disposal. They also frequently include treatment of water from dewatered sediment prior to discharge to an appropriate receiving water body.

Dredging Evaluation Criteria

If properly implemented with measures to manage residuals and control releases, dredging can generally be applied across the Portland Harbor site. The primary limitation of dredging is the presence of debris and structures that may increase releases (e.g., due to failure of the dredge bucket to close) or limit the implementability of dredging due to access or stability concerns. Dredging evaluation criteria to be included in a weight-of-evidence evaluation are presented in **Table 6**. The factors presented in **Table 6** will generally not exclude dredging from consideration but may limit the implementability and cost effectiveness of dredging. Through proper management, many of the factors that limit the short term effectiveness and implementation of dredging can be overcome. Dredging should be considered for all areas that are not suitable for MNR, EMNR or in-situ treatment.

Key elements in the evaluation of dredging include the presence of PTW as NAPL (**Figure 1**), which may increase the potential for short term releases and necessitate the use of more robust water quality controls (e.g., sheet pile containment); the presence of soft sediments (greater than 80% fines, **Figure 3**) which may increase the potential for releases during dredging; the presence of structures (**Figure 8**) and bedrock (**Figure 13**) that may limit the ability to dredge, require the use of specialized dredging equipment or the removal of structures prior to dredging; the presence of debris and pilings (**Figure 9**) which may need to be removed prior to dredging activities or have the potential to increase releases during dredging; high current areas which may limit the effectiveness of silt curtain water quality controls (**Figure 10**); water depth and bottom slope which may require special considerations during implementation of dredging activities (**Figures 11**and **13**); and habitat considerations which may require increased mitigation costs due to disruption of benthic and/or shallow water habitat (**Figure 12**). In the navigation channel and potential future maintenance dredge areas (**Figure 5**), dredging is the most implementable technology as the other technology options require material to be left in place.

Results of Screening Analysis

Sediment Decision Units (SDUs) are the areas identified as focus areas requiring remediation. SDUs are shown on **Figure 14**. CDM Smith will submit a technical memorandum at a later date providing the process and rationale for selecting the SDUs shown on **Figure 14**.

Remedial technologies were screened on a SDU basis to preliminarily identify which technologies would be the most favorable based on site-specific conditions to demonstrate how the criteria discussed above could be applied at the Portland Harbor site. **Tables 2** through **6** present the evaluation criteria used to screen remedial technologies. **Tables 7** through **10** present the results of the preliminary screening evaluation on a SDU basis.

MNR/EMNR

A summary of the MNR/EMNR technology evaluation is presented in **Table 7**. With the exception of SDU River Mile (RM) 6 - 7 East and RM 5.6-6.5 West (except where NAPL is present and offshore of the FAMM dock), MNR/EMNR is generally not expected to be effective at meeting remedial action objectives for sediments due to the lack of sediment deposition and the potential for erosion associated with propwash and wind and vessel generated waves and the potential for future navigation or maintenance dredging activities that would remove recently accumulated material.

For SDU RM 6 – 7 East, there is sufficient sediment deposition in the central portion of Willamette Cove for MNR to be effective. In addition, the lack of wind and vessel generated wave induced erosion, propwash induced erosion and potential for future dredging activities within the central portion of Willamette Cove suggests that any newly deposited clean sediment will remain in place.

For SDU RM 8.1 – 8.9 Swan Island Lagoon, EMNR may be effective for portions of Swan Island Lagoon not subject to beach erosion and propwash induced erosion of future maintenance dredging activities. Although the entire length of Swan Island Lagoon has been identified as a Potential Future Maintenance Dredge Area (**Figure 5**), EMNR may be viable in the upper end of Swan Island Lagoon if deed restrictions are obtained that limit maintenance dredging activities.

Figure 11 shows depth in terms of NAVD88 instead of CRD

For SDU RM 5.1 – 6.7 Navigation Channel, EMNR may be implementable in areas greater than -58 feet CRD. For example, there is a depression located within the Navigation Channel between RM 6 and 6.2. This area is considered a viable candidate for EMNR.

In-Situ Treatment

A summary of the in-situ technology evaluation is presented in **Table 8**. In-situ treatment is considered effective and implementable in areas of stable sediment with concentrations below the in-situ treatment criteria. In-situ treatment criteria have been established at 10 times the lowest applicable PRG for the following COCs for this evaluation:

Figure 11 shows depth in terms of NAVD88 instead of CRD

- PCBs – 200 µg/kg
- Total DDx - 30 µg/kg
- Carcinogenic PAHs as BaPEq - 4,000 µg/kg

For SDU RM 6 – 7 East, in-situ treatment is considered a viable technology for the majority of the SDU with the exception of nearshore areas subject to significant wind and vessel generated waves. In-situ treatment may also be implemented in conjunction with MNR/EMNR to improve the long-term effectiveness of these technologies.

In-situ treatment may is also considered a viable technology for portions of SDUs RM 5.6 -6.5 West (offshore areas without NAPL and not subject to potential future maintenance or dredging activities, in conjunction with EMNR/MNR), RM 8.3 – 9.7 West (areas not subject to wave or propwash induced erosion and future maintenance dredge areas), RM 5.1 -6.7 Navigation Channel (areas below -58 feet CRD) and RM 8.1 – 8.9 Swan Island Lagoon (areas not subject to potential future maintenance dredging assuming appropriate institutional controls are put into place).

Capping

Capping is generally implementable and effective for all SDUs within Portland Harbor with the exception of areas that are subject to potential future navigation or maintenance dredging activities. Although capping is considered implementable within at least a portion of all SDUs, site-specific factors have been identified that may increase the cost of capping. A summary of the capping technology evaluation is presented in **Table 9**.

<u>Principal Threat Waste Present</u>: PTW in the form of NAPL has been identified within SDUs RM 5.6 – 6.5 West and RM 6.6 – 7.9 West. NAPL is expected to increase the cost of capping due to the need for incorporation of an organoclay layer (as bulk organoclay or as an organoclay mat) into the cap design to control the potential for NAPL releases. It should be noted that the use of organoclay in the cap design assumes that effective source control measures have been implemented to reduce the groundwater flux and reduce the potential for NAPL migration that could reduce the sorption capacity of the organophilic clay.

Figure 11 shows depth in terms of NAVD88 instead of CRD

<u>Groundwater Flux Rate</u>: High groundwater flux rates are present for all SDUs along the west side of the Willamette River. While groundwater flux rates are not expected to preclude the use of capping at these SDUs, the use of GAC is needed to increase the long-term effectiveness of caps at SDU RM 8.3 – 9.7 West, SDU Benthic Risk Area 9D-2, and SDU Benthic Risk Area 5-1. GAC is not expected to be necessary to supplement caps on the east side of the Willamette River due to the relatively low groundwater flux rates. At SDUs RM 5.6 – 6.5 West and RM 6.6 – 7.9 West, GAC is not expected to be effective due to the presence of NAPL.

<u>Navigation Requirements</u>: Capping is not considered implementable within the navigation channel except at depths below -58 feet CRD. The only area that meets this criterion is a small area located between RM 6 and 6.2. Capping is also not considered implementable in areas identified as potential future maintenance dredge areas unless the area is 1) not actively used for shipping activities, and 2) institutional controls in the form of navigation restrictions are considered obtainable.

<u>Presence of Structures</u>: Numerous structures are present within all nearshore SDUs with the exception of SDU RM 6 – 7 East. While the placement of sediment cap material around and adjacent to structures is considered implementable, the presence of these structures is expected to increase the cost of capping.

<u>Sediment Bed Slope</u>: Steep slopes are present along the margins of all nearshore SDUs with the exception of SDU RM 6 – 7 East and RM 8.1 – 8.9 Swan Island Lagoon and SDU RM 8.3 – 9.7 West. Capping on steep slopes will require buttressing to prevent the cap from failing. In areas where steep slopes extend to the navigation channel, buttressing may not be implementable due to the potential for creating obstructions within the navigation channel.

<u>Sediment Bed Strength</u>: In general, sediment bed strength is considered sufficient for cap placement in Portland Harbor. However, in some areas of the site, soft sediments (identified as areas with greater than 80% fines) may preclude cost-effective capping. SDUs RM 8.3 – 9.7 West and RM 8.1 -8.9 Swan Island Lagoon have high percentages of very fine-grained sediments and may increase the cost of capping in these areas.

<u>Erosion Potential</u>: Areas of high erosion potential will require the use of an armor layer to ensure that the cap remains in place. Erosion may be caused by wave action, propwash, or high river flow. The primary source of erosion at the Portland Harbor site is wind and vessel generated wave action. With the exception of SDU RM 5.1 – 6.7 Navigation Channel, all SDUs will require at least some armoring of nearshore areas to reduce the potential for wave induced erosion. While armoring is not expected to affect the implementability or effectiveness of capping, the use of armor will increase the cost of capping. In addition, special armoring techniques may be required to limit impacts on aquatic and shallow water habitat.

Dredging

There are no site-specific conditions that would be expected to preclude the use of dredging at the Portland Harbor site. As a result, dredging is considered implementable and effective within all SDUs. The primary factor influencing dredging is the presence of structures which are prevalent throughout Portland Harbor and may limit the ability to remove material below and adjacent to active docks, bulkheads and other structures. A summary of the dredging technology evaluation is presented in **Table 10**.

Principal Threat Waste Present: PTW in the form of NAPL has been identified within SDUs RM 5.6 – 6.5 West and 6.6 – 7.9 West. NAPL is expected to increase the cost of dredging due to the need for additional water quality controls such as silt curtains or sheet pile containment during dredging. During the 2005 removal action at the Gasco site, silt curtains were deployed with bubble curtains. Although the sheet pile controls were 72 – 84% effective, water quality standards were still exceeded 150 feet downstream from the inner containment area during implementation of the removal action. The presence of NAPL is expected to increase the cost of dredging activities due to the need for additional water quality controls and implementation of best management practices which may slow the dredging production rate.

Debris, Pilings, and Utilities: Debris and pilings may require removal prior to dredging. Buried utilities such as gas lines near RM 2.8, a sewer line near RM 7, and a petroleum pipeline near RM 7.7 may preclude conventional dredging at these locations.

Navigation Depth Requirements: Dredging is not expected to interfere with navigation depth requirements. Rather, in areas where navigation depth requirements preclude capping or thin layer placement, dredging is viewed as the preferred technology.

Presence of Structures: The primary limitation to dredging at the Portland Harbor site is the presence of structures. While specialized dredging techniques are available that will allow for dredging below and adjacent to structures, these techniques will increase the cost of dredging. In addition, even with the use of specialized dredging techniques, there are limits to the depth of dredging that can be achieved below and adjacent to structures. While structures can be removed to allow access to contaminated material, removal of structures that are in use is not considered implementable. Removal of dilapidated structures that are no longer in use is considered implementable.

Sediment Bed Slope: Steep slopes are present along the margins of all nearshore SDUs with the exception of SDU RM 6 – 7 East, RM 8.1 – 8.9 Swan Island Lagoon, and RM 8.3-9.7 West. Steep sediment bed slopes may require special engineering considerations to limit releases and residual generation during dredging.

Sediment Bed Strength: SDUs RM 8.3 – 9.7 West and RM 8.1 -8.9 Swan Island Lagoon have a high percentage of soft sediments (identified as areas with greater than 80% fines). Soft sediments within these SDUs may increase the potential for release during dredging activities.

Presence of Bedrock: Bedrock near the sediment surface is generally not present within Portland Harbor with the exception of basalt outcrops within SDU RM 6.6 – 7.9 West where bedrock is present within a few feet of the top of the sediment bed. In addition, localized areas of exposed bedrock may occur in SDUs RM 6 -7 East, RM 5.6 – 6.5 West, and RM 5.1 – 6.7 Navigation Channel, "particularly on the west side of the river near the St. Johns Bridge" (Integral 2011). Areas of bedrock or bedrock exposed near bridge footings may require the use of specialized dredging equipment (e.g., suction based vic-vac device) or containment techniques.

River Current: River current is not expected to limit the effectiveness or implementability of dredging at Portland Harbor SDUs. Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.

Summary

In general, technologies consisting of dredging and capping are considered the most favorable at the Portland Harbor site. While MNR, EMNR and in-situ treatment are considered viable technologies in some areas, the lack of sediment deposition in areas where contaminant concentrations are highest, the potential for erosion due to propwash or wave action, and the potential for future maintenance or navigation dredging is expected to limit the long-term effectiveness of MNR, EMNR and in-situ treatment at the Portland Harbor site.

While capping and dredging are considered applicable to most areas of the Portland Harbor site, further evaluation of site-specific conditions that may influence the effectiveness, implementability, and cost are required to assign technologies to specific areas for the purpose of developing remedial action alternatives for the Portland Harbor site. CDM Smith will submit a technical memorandum on the assignment of technologies to specific areas once agreement has been reached on the screening process and evaluation criteria presented in this document.

References

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Tables

Table 1 - Representative Process Option Identification
Portland Harbor Superfund Site
Portland, Oregon

General Response Action	Remedial Technology	Process Options	Representative Process Option
No Action	None	Not Applicable	Retained as Representative Process Option
Institutional Controls	Government Controls	Commercial Fishing Bans	Limited commercial fishing
		Waterway Use Restrictions or Regulated Navigation Areas	May be used in conjunction with other technologies
	Proprietary Controls	Land Use and Access Restrictions	Limited use expected
		Structure Maintenance Agreements	Limited use expected
	Informational Devices	Fish Consumption Advisories	Retained as Representative Process Option
Monitored Natural Recovery	Monitored Natural Recovery	Monitored Natural Recovery	Retained as Representative Process Option
Enhanced Monitored Natural Recovery	Enhanced Monitored Natural Recovery	Thin Layer Placement	Retained as Representative Process Option
Containment in Place	Conventional Capping	Conventional Sand Cap	Retained as Representative Process Option
		Armored Cap	Price premium for erosion areas
		Composite Cap	Limited use expected
		Habitat Cap	Price premium for habitat areas
	Reactive Cap	Carbon Amendment	Retained as Representative Process Option
In-Situ Treatment	Biological Treatment	Enhanced Bioremediation	Eliminated from consideration
		Phytoremediation	Eliminated from consideration
		Aerobic Biodegradation	Eliminated from consideration
		Anaerobic Biodegradation	Eliminated from consideration
	Physical Treatment	Carbon Amendments	Retained as Representative Process Option
		Solidification/Stabilization	Limited use expected
Removal	Dredging	Mechanical Dredging	Retained as Representative Process Option
		Hydraulic Dredging	May be considered during Remedial Design (RD)
		Excavation	May be considered during RD
		Specialized Dredging	Price premium for structures
Off-Site Disposal	Off Site Disposal	Landfill Disposal	Retained as Representative Process Option
		Upland Placement	Limited use expected

Table 1 - Representative Process Option Identification
Portland Harbor Superfund Site
Portland, Oregon

General Response Action	Remedial Technology	Process Options	Representative Process Option
On-Site Disposal	On-Site Disposal	Confined Disposal Facility (CDF) Disposal	Retained as Representative Process Option
		Confined Aquatic Disposal (CAD) Site Disposal	Eliminated from consideration
Ex-Situ Treatment	Dewatering	In-barge Dewatering	Retained as Representative Process Option
		Lagoon Dewatering	May be considered during RD
		Geotextile Tube Dewatering	May be considered during RD
		Mechanical Dewatering	May be considered during RD
		Reagent Dewatering	May be considered during RD
	Physical	Solidification/Stabilization	Retained as Representative Process Option
		Sediment Washing	May be considered during RD
	Biological	Land Treatment	May be considered during RD
		Composting	May be considered during RD
	Chemical	Solvent/Acid Extraction	Eliminated from consideration
		Chemical Oxidation	Eliminated from consideration
	Thermal	Incineration	Eliminated from consideration
		Thermal Desorption	Eliminated from consideration

Table 2 – Monitored Natural Recovery Evaluation Criteria
Portland Harbor Superfund Site
Portland, Oregon

Line of Evidence	MNR Evaluation Criteria	Basis
Principal Threat Waste	Principal Threat Waste present	Presence of Principal Threat Waste (PTW) in the form of non-aqueous phase liquid (NAPL) will unacceptably limit the effectiveness of monitored natural recovery (MNR) due to the potential for transport to the surface via physical mixing and advective groundwater transport. Areas of PTW in the form of NAPL are presented in **Figure 1.**
Erosion/Deposition Rate	2.5 cm/year	The minimum observable deposition rate based on resolution of bathymetric surveys and 6-year timeframe is 2.5 cm per year rate. A 2.5 cm/year deposition rate is estimated to reduce sediment concentrations through mixing and dilution by 50% over a 10 year period assuming a mixed depth of 30 cm. Areas with a sediment deposition rate greater than 2.5 cm/year are presented in **Figure 2.**
Sediment Grain Size (Percent Fines)	50% fines	Grain size can be used to estimate areas of high and low energy. Percent fines measures the percentage of silts and clays which are also considered cohesive sediments. A percent fines content of greater than 50% fines indicates that the sediment bed is comprised primarily of cohesive sediments and thus is an area of stable sediments amenable to MNR. Areas with a percent fines content greater than 50% are presented in **Figure 3.**
Surface to Subsurface Concentration Ratio	1.0	Areas with surface sediment concentrations higher than subsurface sediments suggests that concentrations are increasing due to an ongoing source of contamination and MNR is not likely to be effective. Areas with surface sediment concentrations greater than subsurface are presented in **Figure 4.**
Dredging and Propwash Areas	Future Potential Dredge Area	Sediment deposition in future potential dredge areas is likely to be removed during future maintenance dredging activities thus limiting the long-term effectiveness of MNR. Future potential dredge areas are also subject to propwash induced erosion further limiting the effectiveness of MNR. Future potential dredge and propwash areas are presented in **Figures 5** and **11**.
Wind and Wake Wave Susceptible Areas	Nearshore areas	Nearshore areas are subject to waves in the 2 to 3 foot range due to wind and vessel traffic. River stage generally fluctuates between -0.5 foot and 14.8 feet Columbia River Datum (CRD; or 4.5 feet and 19.8 feet NAVD88). MNR is deemed ineffective for elevations in this range due to the potential for wave induced erosion. Nearshore areas subject to wind and wake generated waves are presented in **Figure 6.**

Table 3 – EMNR Evaluation Criteria

Portland Harbor Superfund Site
Portland, Oregon

Line of Evidence	EMNR Evaluation Criteria	Basis
Principal Threat Waste	Principal Threat Waste present	Presence of Principal Threat Waste (PTW) in the form of NAPL will unacceptably limit the effectiveness of EMNR due the potential for transport to the surface via physical mixing and advective groundwater transport. Areas of PTW in the form of NAPL are presented in **Figure 1.**
Erosion/Deposition Rate	+/- 2.5 cm/year	Minimum observable deposition rate based on resolution of bathymetric surveys and 6 year timeframe is 2.5 cm per year. A change in sediment bed elevation of +/- 2.5 cm per year suggests that the sediment bed is stable and may be amenable to EMNR. Areas with a sediment deposition rate of +/- 2.5 cm per year are presented in **Figure 2.**
Sediment Grain Size (Percent Fines)	40% fines	Grain size can be used to estimate areas of high and low energy. Percent fines measures the percentage of silts and clays which are also considered cohesive sediments. A percent fines content of greater than 40% fines suggests that the sediment bed is relatively stable and thus amenable to EMNR. Areas with a percent fines content greater 40% are presented in **Figure 3.**
Surface/Subsurface Concentration	1.0	Areas with surface sediment concentrations higher than subsurface sediments suggests that concentrations are increasing due to an ongoing source of contamination and EMNR is not likely to be effective. Areas with surface sediment concentrations greater than subsurface are presented in **Figure 4.**
Dredging and Propwash Areas	Outside all future dredging and berthing areas	Sediment deposition in future potential dredge areas is likely to be removed during future maintenance dredging activities thus limiting the long-term effectiveness of EMNR. Future potential dredge areas are also subject to propwash induced erosion further limiting the effectiveness of EMNR. Future potential dredge and propwash areas are presented in **Figures 5** and **11.**
Wind and Wake Wave Susceptible Areas	Nearshore areas	Nearshore areas are subject to waves in the 2 to 3 foot range due to wind and vessel traffic. River stage generally fluctuates between -0.5 foot and 14.8 feet Columbia River Datum (CRD; 4.5 feet and 19.8 feet NAVD88). EMNR is deemed ineffective for elevations in this range due to the potential for wave induced erosion. Nearshore areas between -0.5 foot and 14.8 feet CRD subject to wind and wake generated waves are presented in **Figure 6.**

Table 4 – In-Situ Treatment Evaluation Criteria

Portland Harbor Superfund Site
Portland, Oregon

Line of Evidence	In-Situ Treatment Evaluation Criteria	Basis
Chemical Composition and Concentration	Contaminants for which in-situ treatment is proven effective	In-situ treatment has been demonstrated at the pilot scale for organic compounds such as PAHs, DDT and PCBs. Pilot scale data suggest that in-situ treatment can reduce contaminant bioavailability by 90% (Ghosh et. al, 2011; Tomaszewski et. al., 2008; Zimmerman et. al., 2005). In-situ treatment criteria have been established for PCBs (200 micrograms per kilogram [µg/kg]), total DDx (30 µg/kg) and carcinogenic PAHs as benzo(a)pyrene equivalents (4,000 µg/kg). Areas with sediment concentrations below the in-situ treatment threshold are presented in **Figure 7.**
Erosion/Deposition Rate	+/- 2.5 cm/year	The minimum observable deposition rate based on resolution of bathymetric surveys and 6 year timeframe is 2.5 cm per year. A change in sediment bed elevation of +/- 2.5 cm per year suggests that the sediment bed is stable and may be amenable to in-situ treatment. Areas with a sediment deposition rate of +/- 2.5 cm per year are presented in **Figure 2.**
Sediment Grain Size (Percent Fines)	> 40% fines	Grain size can be used to estimate areas of high and low energy. Percent fines measures the percentage of silts and clays which are also considered cohesive sediments. A percent fines content of greater than 40% fines suggests that the sediment bed is relatively stable and thus amenable to in-situ treatment. Areas with a percent fines content greater than 40% are presented in **Figure 3.**
Surface/Subsurface Concentration	>1.0	Areas with surface sediment concentrations higher than subsurface sediments suggests that concentrations are increasing due to an ongoing source of contamination and in-situ treatment (i.e., use of amendments) is not likely to be effective. Areas with surface sediment concentrations greater than subsurface are presented in **Figure 4.**
Dredging and Propwash Areas	Outside all future dredging and berthing areas	Sediment deposition in future potential dredge areas is likely to be removed during future maintenance dredging activities thus limiting the long-term effectiveness of in-situ treatment (i.e., use of amendments). Future potential dredge areas are also subject to propwash induced erosion further limiting the effectiveness of in-situ treatment. Future potential dredge and propwash areas are presented in **Figures 5 and 11.**
Wind and Wake Wave Susceptible Areas	Nearshore areas	Nearshore areas are subject to waves in the 2 to 3 foot range due to wind and vessel traffic. River stage generally fluctuates between -0.5 foot and 14.8 feet Columbia River Datum (CRD; 4.5 feet and 19.8 feet NAVD88). In-situ treatment (i.e., use of amendments) is deemed ineffective for elevations in this range due to the potential for wave induced erosion. Nearshore areas between -0.5 foot and 14.8 feet CRD subject to wind and wake generated waves are presented in **Figure 6.**

Table 4 – In-Situ Treatment Evaluation Criteria
Portland Harbor Superfund Site
Portland, Oregon

Line of Evidence	In-Situ Treatment Evaluation Criteria	Basis
Groundwater Flux Rate	Areas of high groundwater flux rate	In-situ treatment may be used to augment MNR or EMNR in areas where groundwater flux rates greater than 1 cm/day are present. Precise estimates of groundwater flux rate are not known across the site. However, due to generally high groundwater flux rates on the west site of the river and lower flux rates on the east site of the river, EMNR areas on the west side of the Willamette River would benefit from incorporation of activated carbon to reduce contaminant flux associated with advective groundwater transport.
Presence of Structures	Presence of structures	In-situ treatment may be favorable in areas were structures limit application of dredging and/or capping technologies. Areas with structures that may limit application of dredging and capping technologies and favor in-situ treatment are presented in **Figure 8.**
Presence of Habitat Areas	Presence of habitat areas	In-situ treatment may be favorable in areas where application of dredging and/or capping technologies may result in significant habitat destruction. Areas of significant habitat or identified as potential restoration areas are presented in **Figure 12.**

Table 5 – Capping Evaluation Criteria
Portland Harbor Superfund Site
Portland, Oregon

Line of Evidence	Capping Evaluation Criteria	Basis
Principal Threat Waste	Principal Threat Waste (NAPL) cannot be capped using standard capping techniques	Principal Threat Waste (PTW) in the form of NAPL can generally only be capped if organoclay amendments are incorporated into the cap design and construction. Areas of PTW in the form of NAPL are presented in **Figure 1.**
Sediment Bed Strength	Sediment grain size	Undrained shear strength data is not available. However, an indication of sediment bed strength may be estimated based on sediment grain size. Sediment with greater than 80% fines are expected to be soft and may require more care in design/placement. Sediment grain size as percent fines is presented in **Figure 3**.
Groundwater Flux Rate	Areas of high groundwater flux rate	Due to generally high groundwater flux rates on the west site of the river and lower flux rates on the east site of the river, areas amenable to capping on the west side of the Willamette River would benefit from incorporation of activated carbon to reduce contaminant flux associated with advective groundwater. Areas on the east side of the river may be capped with standard sand caps.
Dredging and Propwash Areas	Outside all future dredging and berthing areas	Capping within future maintenance dredge areas is generally not considered implementable unless institutional controls limiting water way use are obtained. Future potential dredge areas are also subject to propwash induced erosion which may require application of an armoring layer. Future potential dredge and propwash areas are presented in **Figures 5** and **11.**
Wind and Wake Wave Susceptible Areas	Nearshore areas	Nearshore areas are subject to waves in the 2 to 3 foot range due to wind and vessel traffic. River stage generally fluctuates between -0.5 foot and 14.8 feet Columbia River Datum (CRD; 4.5 feet and 19.8 feet NAVD88). Areas subject to high wave induced erosion potential must be appropriately armored. Nearshore areas between -0.5 foot and 14.8 feet CRD subject to wind and wake generated waves are presented in **Figure 6.**
Presence of Structures	Capping can be performed beneath structures. Cap thickness may be limited.	Capping can be performed beneath structures. Reactive caps can be used in areas where cap thickness is limited. Structures that are likely to affect the cost and implementability of capping are presented in **Figure 8**.
Debris and Pilings	Presence of debris and pilings	Debris can generally be managed for capping projects. Surface debris and pilings can be removed. The presence of debris and pilings is likely to increase the cost of capping. Areas containing debris and pilings are presented in **Figure 9.**

Table 5 – Capping Evaluation Criteria
Portland Harbor Superfund Site
Portland, Oregon

Line of Evidence	Capping Evaluation Criteria	Basis
Erosion Potential (Current)	Modeled bottom shear force during high flow event (160,000 cubic feet per second)	Areas of high bottom shear (greater than 1 Pascal [Pa]) during high flow events may require special armoring considerations. Areas of modeled bottom shear are presented in **Figure 10**.
Water Depth Requirements	Navigation channel and potential future maintenance dredge areas	Capping is generally not permitted within the navigation channel or berthing areas. Capping is not considered implementable in the navigation channel at depths less than -58 feet CRD. Capping within potential future maintenance dredge areas is also not considered implementable unless the area is unlikely to be dredged and institutional controls limiting dredging activities are secured. Water depth is presented in **Figure 11.**
Sediment Bed Slope	Sediment bed slope based on site bathymetry	Sediment bed slopes less than 7:1 will not require any special considerations. Sediment bed slopes between 7:1 and 3:1 can be capped with special engineering considerations. Sediment slopes greater than 3:1 are generally not amenable to capping. Information regarding liquefaction potential, slope stability, and sediment shear strength will be required to properly design sediment caps on slopes greater than 7:1. Site slopes are presented in **Figure 13.**
Presence of Habitat Areas	Presence of habitat areas	Habitat areas can be capped as long as a suitable habitat layer is used for the surface of the cap. Heavy armoring is not allowed (cobbles are acceptable). Areas of significant habitat or identified as potential restoration areas are presented in **Figure 12.**

Figure 11 shows depth in terms of NAVD88 instead of CRD

Table 6 – Dredging Evaluation Criteria

Portland Harbor Superfund Site
Portland, Oregon

Criteria	Dredging Evaluation Criteria	Mapping Notes
Principal Threat Waste Present	Principal Threat Waste	Hydraulic dredging is not suitable for Principal Threat Waste (PTW) in the form of NAPL. The presence of NAPL requires use of mechanical dredging with a closed bucket. The presence of PTW (NAPL) may require the use of sheet pile controls. Areas of PTW in the form of NAPL are presented in **Figure 1.**
Sediment Bed Strength	Percent fines > 80%	Soft sediments may be more easily removed using hydraulic dredging. Mechanical dredging of soft sediments may increase release rates and necessitate more robust water quality controls. Undrained shear strength data is not available. However, an indication of sediment bed strength may be estimated based on sediment grain size. Sediment with greater than 80% fines is expected to be soft and may require more robust water quality controls. Sediment grain size as percent fines is presented in **Figure 3**.
Water Depth Requirements	Navigation channel and potential future maintenance dredge areas	Dredging may be more favorable in navigation and berthing areas because technologies that require material to be left in place are generally not implementable. Potential future maintenance dredge areas are presented in **Figure 5.** Water depth is presented in **Figure 11.**
Presence of Structures	Presence of structures	The presence of structures may reduce the feasibility of dredging and may necessitate the use of barge mounted excavators with narrow buckets. The use of barge mounted excavators with open buckets may increase releases during dredging and necessitate more robust water quality controls. Structures that are likely to affect the cost and implementability of dredging are presented in **Figure 8**.
Debris and Pilings	Presence of debris and pilings	The type of debris present will influence the selection of dredging equipment. The presence of debris may increase releases during dredging and/or necessitate more robust water quality controls. Surface debris and pilings can be removed. A high density of pilings and debris is likely to increase cost of dredging. Areas with pilings and debris are presented in **Figure 9.**
Water Depth	Water depth greater than 40 feet	Water depth within the Willamette River is not expected to influence the selection of dredging equipment. However, dredging in deep water may limit the effectiveness of silt curtain controls and the implementability of sheet pile controls. Water depth is presented in **Figure 11.**

Table 6 – Dredging Evaluation Criteria
Portland Harbor Superfund Site
Portland, Oregon

Criteria	Dredging Evaluation Criteria	Mapping Notes
Sediment Bed Slope	Slopes greater than 3:1 based on site bathymetry	Removal to a defined slope is difficult for all dredging methods. Fixed arm mechanical dredging is more effective on steep slopes but is limited to depths of 20 to 25 feet. Dredging on steep slopes may increase releases during dredging due to sloughing and necessitate more robust water quality controls. Sediment bed slopes less than 7:1 will not require any special dredging considerations. Sediment bed slopes between 7:1 and 3:1 can be dredged with special engineering considerations. Sediment slopes greater than 3:1 will require the use of coarse buttress rock or armor. Information regarding liquefaction potential, slope stability, and sediment shear strength will be required to properly design dredging projects on steep slopes. Site slopes are presented in **Figure 13.**
Erosion Potential (Current)	Current > 2 miles per hour (mph)	Areas where the current is greater than 2 mph are suitable for hydraulic or mechanical dredging, or excavation. Silt curtains may be ineffective in high current areas (greater than 2 mph).
Presence of Bedrock and Hardpan	Presence of bedrock and hardpan	The presence of bedrock or hardpan may influence the selection of dredging equipment, may necessitate the use of suction devices as a polishing step, may increase releases during dredging, and may necessitate more robust water quality controls. Areas of bedrock and hardpan are presented in **Figure 13.**
Presence of Habitat Areas	Presence of habitat areas	Habitat areas can be dredged but increased mitigation costs may need to be taken into consideration. Areas of significant habitat or identified as potential restoration areas are presented in **Figure 12.**

No figure currently shows current velocity (mph).

Table 7 - MNR/EMNR Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Sediment Deposition Rate (Figure 2)	Sediment Grain Size (Figure 3)	Surface to Subsurface Sediment Concentration Ratio (Figure 4)	Propwash Area (Figure 11)	Future Dredge Area (Figure 5)	Wind and Wake Wave Area (Figure 6)	MNR Evaluation Summary
RM 1.6 – 2.8 East	No principal threat waste present.	Sediment deposition rates are generally less than 2.5 cm/year or unknown due to bathymetric change survey limitations.	Nearshore sediments are less than 20% fines.	Subsurface sediment concentrations exceed surface sediment concentrations for key chemicals of concern (COCs).	Sediment contamination is generally outside propwash areas (outside dock areas).	Sediment contamination is generally outside potential future maintenance dredging areas (outside dock areas)	Nearshore areas subject to wind and vessel generated waves.	MNR/EMNR is not considered a viable technology due to lack of sediment deposition, large grain size and potential for wave-induced erosion.
RM 3.2 – 4.1 East	No principal threat waste present.	Sediment deposition rates in upper end of International Slip are generally greater than 2.5 cm/year. Sediment deposition rates in the main channel are unknown due to bathymetric change survey limitations.	Sediment grain size is generally greater than 50% fines in areas exceeding the remedial action level (RAL) of 200 micrograms per kilogram (µg/kg).	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion in International Slip and main channel.	Majority of area has been identified as a potential future maintenance dredge area.	Nearshore areas in main channel are subject to wind and vessel generated waves.	Although the area is generally depositional, EMNR/MNR is not considered a viable technology due to propwash potential, potential for future maintenance dredging activities, and potential for wave-induced erosion in the main channel.
RM 4.2 – 5.0 East	No principal threat waste present.	Sediment deposition rates generally exceed 2.5 cm/year.	Although sediment grain size is variable, a significant percentage of the area is coarse-grained sediment.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion within slips.	Majority of area has been identified as a potential future maintenance dredge area.	Nearshore areas of Wheeler Bay have been identified as subject to wind and vessel generated waves.	Although the area is generally depositional, EMNR/MNR is not considered a viable technology due to propwash potential, potential for future maintenance dredging activities, and potential for wave-induced erosion in Wheeler Bay.
RM 6.0 – 7.0 East	No principal threat waste present.	With the exception of the center portion of Willamette Cove, sediment deposition rates are less than 2.5 cm/year.	With the exception of the center portion of Willamette Cove, the majority of the area is coarse-grained sediment.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Area is generally not subject to propwash.	Area has not been identified as a potential future maintenance dredge area.	Nearshore areas subject to wind and vessel generated waves.	EMNR/MNR is considered a viable technology for contaminated sediments within the central portion of Willamette Cove.

Table 7 - MNR/EMNR Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Sediment Deposition Rate (Figure 2)	Sediment Grain Size (Figure 3)	Surface to Subsurface Sediment Concentration Ratio (Figure 4)	Propwash Area (Figure 11)	Future Dredge Area (Figure 5)	Wind and Wake Wave Area (Figure 6)	MNR Evaluation Summary
RM 10.6 – 11.6 East	No principal threat waste present.	Sediment deposition rates are variable and generally less than 2.5 cm/year.	The vast majority of sediments are less than 20% fines.	Surface sediment concentrations exceed subsurface sediment concentrations for key COCs.	Significant potential for propwash-induced erosion due to presence of docks and turning basin.	The area offshore of the docks is regularly dredged and has been identified as a potential future maintenance dredge area.	Area is generally not subject to wind and vessel generated wave erosion.	EMNR/MNR is not considered a viable technology due to the lack of sediment deposition, lack of fine-grained sediments, potential for propwash-induced erosion, potential for future maintenance dredging activities, and presence of surface sediment contamination at concentrations higher than subsurface sediment concentrations.
RM 5.6 – 6.5 West	Principal threat waste in the form of NAPL is present.	Sediment deposition rates in offshore areas are generally greater than 2.5 cm/year. Sediment deposition rates in nearshore areas are unknown due to bathymetric change survey limitations.	Offshore sediments are generally fine-grained. Nearshore sediments are generally coarse-grained.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion offshore of FAMM dock.	The area offshore of the FAMM dock has been identified as a potential future maintenance dredge area.	Nearshore areas subject to wind and vessel generated waves.	EMNR/MNR is considered a viable technology for offshore sediments with the exception of where NAPL is present and offshore of the FAMM dock.
RM 6.6 – 7.9 West	Principal threat waste in the form of NAPL is present.	Sediment deposition rates are generally less than 2.5 cm/year or are unknown due to bathymetric change survey limitations.	Offshore sediments are generally fined-grained. Nearshore sediments are generally coarse-grained.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion offshore of Arkema docks.	The area offshore of the Arkema docks has been identified as a potential future maintenance dredge area.	Nearshore areas subject to wind and vessel generated waves.	EMNR/MNR is not considered a viable technology due to the presence of NAPL, lack of sediment deposition, potential for wind, wake and propwash-induced erosion and potential for future maintenance dredging activities.
RM 8.3 – 9.7 West	No principal threat waste present.	Sediment deposition rates in offshore areas between RM 8.6 and 9.2 are greater than 2.5 cm/year.	Sediments are generally fine-grained with the exception of nearshore sediments between RM 9.2 and 9.7.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion offshore of Shell dock and Shaver Transportation tugboat facility.	Numerous potential future maintenance dredge areas identified.	Nearshore areas subject to wind and vessel generated waves.	With the exception of some offshore areas, EMNR/MNR is not considered a viable technology due to the potential for wind, wake and propwash-induced erosion and potential for future maintenance dredging activities.

Table 7 - MNR/EMNR Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Sediment Deposition Rate (Figure 2)	Sediment Grain Size (Figure 3)	Surface to Subsurface Sediment Concentration Ratio (Figure 4)	Propwash Area (Figure 11)	Future Dredge Area (Figure 5)	Wind and Wake Wave Area (Figure 6)	MNR Evaluation Summary
RM 5.1 – 6.7 Navigation Channel	No principal threat waste present.	Sediment deposition rates are variable and generally less than 2.5 cm/year.	Sediments are generally coarse-grained.	Surface sediment concentrations exceed subsurface sediment concentrations for key COCs in some areas.	Limited potential for propwash due to water depth (sediment bed elevation greater than -50 feet Columbia River Datum [CRD]).	Potential for channel deepening activities.	Area is not subject to wind and vessel generated wave erosion.	MNR is not considered viable due to the lack of sediment deposition, presence of coarse-grained sediment and potential for future channel deepening activities. EMNR may be implementable in areas greater than -58 feet CRD.
RM 8.1 – 8.9 Swan Island Lagoon	No principal threat waste present.	Sediment deposition rates are in the 1.25 – 2.5 cm/year range with the exception of the far upstream end of Swan Island Lagoon where deposition rates are somewhat lower.	The majority of the sediments exceed 50% fines with the exception of some nearshore areas.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	The lower end of Swan Island Lagoon is subject to propwash.	All of Swan Island Lagoon has been identified as a potential future maintenance dredge area.	Potential for wind and vessel generated wave erosion along the northeast shore of Swan Island Lagoon.	MNR is not considered a viable technology due to sediment deposition rates below the 2.5 cm/year threshold and the potential for future maintenance dredging activities. EMNR may be implementable in the upper end of Swan Island Lagoon if navigation restrictions are put in place to limit dredging in the upper end of Swan Island Lagoon.

Figure 11 shows depth in terms of NAVD88 instead of CRD

Table 8 – In-Situ Treatment Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Contaminant Concentration (Figure 4)	Sediment Deposition Rate (Figure 2)	Sediment Grain Size (Figure 3)	Surface to Subsurface Sediment Concentration Ratio (Figure 4)	Propwash Area (Figure 11)	Future Dredge Area (Figure 5)	Wind and Wake Wave Area (Figure 6)	In-Situ Treatment Evaluation Summary
RM 1.6 – 2.8 East	Polychlorinated biphenyls (PCBs) are present in surface sediments at concentrations greater than the treatment threshold of 200 micrograms per kilogram (µg/kg) across a significant portion of this Sediment Decision Unit (SDU).	Sediment deposition rates are generally less than 2.5 cm/year or unknown due to bathymetric change survey limitations.	Nearshore sediments are less than 20% fines.	Subsurface sediment concentrations exceed surface sediment concentrations for key chemicals of concern (COCs).	Sediment contamination is generally outside propwash areas (outside dock areas).	Sediment contamination is generally outside potential future maintenance dredging areas (outside dock areas).	Nearshore areas are subject to wind and vessel generated waves.	In-situ treatment is not considered a viable technology due to PCB concentrations exceeding the treatment threshold and the potential for wave-induced erosion.
RM 3.2 – 4.1 East	PCBs are present in surface sediments at concentrations greater than the treatment threshold of 200 µg /kg along the southern portion of the International Slip and along the shoreline in the main river channel.	Sediment deposition rates in the upper end of International Slip are generally greater than 2.5 cm/year. Sediment deposition in the main channel are unknown due to bathymetric change survey limitations.	Sediment grain size is generally greater than 50% fines in areas exceeding the remedial action level (RAL) of 200 µg/kg.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion in International Slip and main channel.	Majority of area has been identified as a potential future maintenance dredge area.	Nearshore areas in the main channel are subject to wind and vessel generated waves.	In-situ treatment is not considered a viable technology due to PCB concentrations exceeding the treatment threshold, propwash potential, potential for future maintenance dredging activities, and potential for wave-induced erosion in the main channel.
RM 4.2 – 5.0 East	Carcinogenic polycyclic aromatic hydrocarbon (PAH) concentrations are generally above the treatment threshold of 4,000 µg/kg benzo(a)pyrene equivalent (BaPEq).	Sediment deposition rates generally exceed 2.5 cm/year.	Although sediment grain size is variable, a significant percentage of the area is coarse-grained sediment.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash induced erosion within slips.	Majority of area has been identified as a potential future maintenance dredge area.	Nearshore areas of Wheeler Bay have been identified as subject to wind and vessel generated wave areas.	In-situ treatment is not considered viable due to sediment concentrations above the BaPEq treatment threshold, propwash potential, and potential for future maintenance dredging activities. Although BaPEq sediment concentrations are below the treatment threshold in Wheeler Bay, in-situ treatment is not considered viable due to the potential for wave-induced erosion.

Table 8 – In-Situ Treatment Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Contaminant Concentration (Figure 4)	Sediment Deposition Rate (Figure 2)	Sediment Grain Size (Figure 3)	Surface to Subsurface Sediment Concentration Ratio (Figure 4)	Propwash Area (Figure 11)	Future Dredge Area (Figure 5)	Wind and Wake Wave Area (Figure 6)	In-Situ Treatment Evaluation Summary
RM 6.0 – 7.0 East	PCB concentrations are below the treatment threshold of 200 µg/kg across the majority of this SDU.	With the exception of the center portion of Willamette Cove, sediment deposition rates are less than 2.5 cm/year.	With the exception of the center portion of Willamette Cove, the majority of the area is coarse-grained sediment.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Area is generally not subject to propwash.	Area has not been identified as a potential future maintenance dredge area.	Nearshore areas are subject to wind and vessel generated waves.	In-situ treatment is considered a viable technology for the majority of this area with the exception of nearshore areas subject to significant wind and vessel generated waves.
RM 10.6 – 11.6 East	PCBs are present in surface sediments at concentrations greater than the treatment threshold of 200 µg/kg across the majority of this SDU.	Sediment deposition rates are variable and generally less than 2.5 cm/year.	The vast majority of sediments are less than 20% fines.	Surface sediment concentrations exceed subsurface sediment concentrations for key COCs.	Significant potential for propwash-induced erosion due to presence of docks and turning basin.	The area offshore of the docks is regularly dredged and has been identified as a potential future maintenance dredge area.	Area is generally not subject to wind and vessel generated wave erosion.	In-situ treatment is not considered a viable technology due to PCB concentrations exceeding the treatment threshold, the potential for propwash-induced erosion and potential for future maintenance dredging activities.
RM 5.6 – 6.5 West	Carcinogenic PAHs are present at concentrations well above the treatment threshold. Principal threat waste is present (non-aqueous phase liquid [NAPL]).	Sediment deposition rates in offshore areas are generally greater than 2.5 cm/year. Sediment deposition rates in nearshore areas are unknown due to bathymetric change survey limitations.	Offshore sediments are generally fine-grained. Nearshore sediments are generally coarse-grained.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion offshore of FAMM dock.	The area offshore of the FAMM dock has been identified as a potential future maintenance dredge area.	Nearshore areas are subject to wind and vessel generated waves.	In-situ treatment is not considered viable as a stand-alone technology. In-situ treatment may be viable in conjunction with EMNR/MNR for offshore sediments outside the NAPL zone, future potential dredge areas off shore of the FAMM dock, and in the navigation channel at depths greater than -58 feet Columbia River Datum (CRD).
RM 6.6 – 7.9 West	Total DDx is present in surface sediments at concentrations well above the treatment threshold. Principal threat waste is present (NAPL).	Sediment deposition rates are generally less than 2.5 cm/year or are unknown due to bathymetric change survey limitations.	Offshore sediments are generally fine-grained. Nearshore sediments are generally coarse-grained.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion offshore of Arkema docks.	The area offshore of the Arkema docks has been identified as a potential future maintenance dredge area.	Nearshore areas are subject to wind and vessel generated waves.	In-situ treatment is not considered a viable technology due to total DDx concentrations exceeding the treatment threshold, the presence of NAPL, lack of sediment deposition, potential for wind, wake and propwash-induced erosion and potential for future maintenance dredging activities.

Table 8 – In-Situ Treatment Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Contaminant Concentration (Figure 4)	Sediment Deposition Rate (Figure 2)	Sediment Grain Size (Figure 3)	Surface to Subsurface Sediment Concentration Ratio (Figure 4)	Propwash Area (Figure 11)	Future Dredge Area (Figure 5)	Wind and Wake Wave Area (Figure 6)	In-Situ Treatment Evaluation Summary
RM 8.3 – 9.7 West	PCBs are present in surface sediments above the in-situ treatment threshold at localized areas within this SDU.	Sediment deposition rates in offshore areas between RM 8.6 and 9.2 are greater than 2.5 cm/year.	Sediments are generally fine-grained with the exception of nearshore sediments between RM 9.2 and 9.7	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	Potential for propwash-induced erosion offshore of Shell dock and Shaver Transportation tugboat facility.	Numerous potential future maintenance dredge areas identified.	Nearshore areas are subject to wind and vessel generated waves.	In-situ treatment is considered a viable technology with the exception of areas subject to wind, wake and propwash induced erosion and potential for future maintenance dredging activities.
RM 5.1 – 6.7 Navigation Channel	No principal threat waste present.	Sediment deposition rates are variable and generally less than 2.5 cm/year.	Sediments are generally coarse-grained.	Surface sediment concentrations exceed subsurface sediment concentrations for key COCs in some areas.	Limited potential for propwash due to water depth (sediment bed elevation is greater than -50 feet CRD).	Potential for channel deepening activities.	Area is not subject to wind and vessel generated wave erosion.	In-situ treatment is not considered viable due to the potential for future channel deepening activities. In addition, high concentrations of PAHs in some areas may limit the effectiveness of in-situ treatment. In-situ treatment in conjunction with EMNR may be implementable in areas greater than -58 feet CRD.
RM 8.1 – 8.9 Swan Island Lagoon	No principal threat waste present.	Sediment deposition rates are in the 1.25 – 2.5 cm/year range with the exception of the far upstream end of Swan Island Lagoon where deposition rates are somewhat lower.	The majority of the sediments exceed 50% fines with the exception of some nearshore areas.	Subsurface sediment concentrations exceed surface sediment concentrations for key COCs.	The lower end of Swan Island Lagoon is subject to propwash.	All of Swan Island Lagoon has been identified as a potential future maintenance dredge area.	Potential for wind and vessel generated wave erosion along the northeast shore of Swan Island Lagoon	In-situ treatment is not considered a viable technology due to the potential for future maintenance dredging activities. High concentrations of PCBs and the presence of metals may limit the effectiveness of in situ-treatment. In-situ treatment in conjunction with EMNR may be implementable in the upper end of Swan Island Lagoon if navigation restrictions are put in place to limit dredging in the upper end of Swan Island Lagoon.

Figure 11 shows depth in terms of NAVD88 instead of CRD

Table 9 – Capping Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Ground Water Flux Rate	Water Depth (Figures 5 & 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Bed Strength (Figure 3)	Erosion Potential (Figures 6, 10 & 11)	Capping Evaluation Summary
RM 1.6 – 2.8 East	No principal threat waste present.	Low groundwater flux rate allows placement of conventional sand cap.	Cap placement offshore of dock areas is not implementable due to navigation requirements.	The presence of dock structures will increase the cost of cap placement.	Steep sediment slopes may require special engineering considerations for cap design and placement.	Sediment strength is sufficient for cap placement based on grain size less than 80% fines.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. Nearshore areas are not subject to high current-induced shear forces during typical high flow events (e.g., 160,000 cubic feet per second [cfs]).	Capping is considered a viable remedial technology for areas outside the navigation channel and berthing areas. Special engineering considerations will be required to address sediment bed slope, cap placement beneath structures, and wind and vessel generated waves.
RM 3.2 – 4.1 East	No principal threat waste present.	Low groundwater flux rate allows placement of conventional sand cap.	Cap placement in lower portion of International Slip and offshore of Schnitzer docks is not implementable due to navigation requirements.	The presence of dock structures in main channel will increase the cost of cap placement. Capping in International Slip is unimpeded by structures.	Steep slopes that would impede cap placement are not present within International Slip or in nearshore areas of the main channel. Capping on the margins of the navigation channel may require special engineering considerations for cap design and placement.	In general, sediment strength is sufficient for cap placement based on grain size less than 80% fines. However, soft sediments may be present in upper end of International Slip.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. Nearshore areas are not subject to high current-induced shear forces during typical high flow events (e.g., 160,000 cfs).	Capping is generally implementable with the exception of areas in the International Slip and main channel offshore of the Schnitzer docks that have been identified as potential future maintenance dredge areas. Nearshore areas may require armoring. However armoring is not required for current-induced flows. Structures within the main channel may require special considerations during cap design and placement.
RM 4.2 – 5.0 East	No principal threat waste present.	Low groundwater flux rate allows placement of conventional sand cap.	Cap placement within Terminal 4 Slips 1 and 3 is not implementable due to navigation requirements. No depth requirements exist within Wheeler Bay.	The presence of dock structures within Slips 1 and 3 main channel will increase the cost of cap placement.	Steep slopes along the margins of Slips 1 and 3 may require special engineering considerations for cap design and placement.	Areas of fine-grained sediment (greater than 80% fines) may require specialized cap placement techniques.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. Nearshore areas are not subject to high current-induced shear forces during typical high flow events (e.g., 160,000 cfs).	Capping is generally not implementable due to navigation requirements. The presence of structures, steep slopes, and soft sediments will require special considerations during cap design and placement. Capping is considered implementable within Wheeler Bay but will requiring armoring to resist wind and vessel generated wave induced erosion.

Table 9 – Capping Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Ground Water Flux Rate	Water Depth (Figures 5 & 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Bed Strength (Figure 3)	Erosion Potential (Figures 6, 10 & 11)	Capping Evaluation Summary
RM 6.0 – 7.0 East	No principal threat waste present.	Low groundwater flux rate allows placement of conventional sand cap.	There are no water depth requirements that would limit the implementability of cap placement.	No significant structures are present that would limit cap placement. Cap design will have to be compatible with adjacent McCormick and Baxter cap.	Sediment bed slope is not expected to limit the implementability of cap placement.	Sediment strength is sufficient for cap placement based on grain size less than 80% fines. Small area of fine-grained sediments within central portion of Willamette Cove (greater than 80% fines).	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. Nearshore areas are not subject to high current induced shear forces during typical high flow events (e.g., 160,000 cfs).	Capping is generally implementable at Willamette Cover. Armoring in nearshore areas may not be compatible with future land and waterway use.
RM 10.6 – 11.6 East	No principal threat waste present.	Low groundwater flux rate allows placement of conventional sand cap.	Capping is not implementable offshore of Glacier Northwest and Goldendale Aluminum docks due to navigation requirements.	The presence of dock structures and other infrastructure (e.g., dolphins) will increase the cost of cap placement. Removal of dilapidated structures will likely facilitate cap placement.	Steep slopes along the margin of the navigation channel may limit the implementability of cap placement.	Sediment strength is sufficient for cap placement based on grain size less than 80% fines.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. High shear forces during high flow events and propwash potential may also require armoring.	Capping is not implementable offshore of existing docks. Capping may be implementable in areas with shallow slope behind dock structures.
RM 5.6 – 6.5 West	Principal threat waste present (non-aqueous phase liquid [NAPL]).	High groundwater flux rate and presence of NAPL will require use of organoclay mat or similar reactive layer.	Capping is not implementable offshore of the FAMM dock and within the navigation channel due to navigation requirements.	The FAMM dock will increase the cost of cap placement. Numerous dilapidated structures are present. Removal of these structures will likely facilitate cap placement.	Steep slopes along the margin of the navigation channel may limit the implementability of cap placement.	Sediment strength appears to be sufficient for cap placement based on grain size less than 80% fines. Fine-grained sediments are present along the margin of the navigation channel.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. High current induced shear forces are possible	Capping is implementable in nearshore areas. Due to the presence of NAPL in subsurface sediments and high groundwater flux, capping will require the use of organoclay mats or similar reactive materials and effect hydraulic control of groundwater discharges. High current and wave induced erosion potential will require armoring. Capping is not implementable offshore of the FAMM dock nor in the navigation channel.

Table 9 – Capping Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Ground Water Flux Rate	Water Depth (Figures 5 & 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Bed Strength (Figure 3)	Erosion Potential (Figures 6, 10 & 11)	Capping Evaluation Summary
RM 6.6 – 7.9 West	Principal threat waste present (NAPL).	High groundwater flux rate and presence of NAPL will require use of organoclay mat or similar reactive layer.	Capping is not implementable offshore of the Arkema docks and within the navigation channel due to navigation requirements.	The presence of the three large dock structures offshore of the Arkema facility will increase the cost of cap placement.	Steep slopes along the margin of the navigation channel may limit the implementability of cap placement.	Sediment strength appears to be sufficient for cap placement based on grain size less than 80% fines. Fine-grained sediments are present along the margin of the navigation channel.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. High current induced shear forces are possible.	Capping is implementable in nearshore areas. Due to the presence of NAPL in subsurface sediments and high groundwater flux, capping will require the use of organoclay mats or similar reactive materials and effect hydraulic control of groundwater discharges. High current and wave induced erosion potential will require armoring. Capping is not implementable offshore of the Arkema docks and in the navigation channel.
RM 8.3 – 9.7 West	No principal threat waste present.	High groundwater flux rate will require use of granular activated carbon layer or similar material.	Capping is not implementable offshore of the Shell dock, Shaver dock, and within the navigation channel due to navigation requirements.	Numerous structures will increase the cost of cap placement. Structures no longer in use may be removed to facilitate cap placement.	Steep slopes are generally not present due to shoaling that has occurred in the upstream portion of this Sediment Decision Unit (SDU). Steep slopes offshore of the Shell dock may limit the implementability of cap placement.	Fine-grained sediments (greater than 80% fines) are present throughout a large portion of this SDU and may require specialized cap placement techniques.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring. Current induced shear forces are generally low.	Capping is implementable in nearshore areas outside the navigation channel and potential future maintenance dredge areas. The presence of numerous structures and fine-grained sediments may require special considerations during cap design and placement. High wave induced erosion potential will require armoring in nearshore areas.
RM 5.1 – 6.7 Navigation Channel	No principal threat waste present.	Low groundwater flux rate allows placement of conventional sand cap.	Capping is not implementable within the navigation channel.	No structures are present that would limit the implementability of cap placement.	Steep slopes are not present that would limit the implementability of cap placement.	Sediment strength appears to be sufficient for cap placement based on grain size less than 80% fines.	High current induced shear forces may require armoring.	Capping within the navigation channel is not considered implementable.
RM 8.1 – 8.9 Swan Island Lagoon	No principal threat waste present.	Low groundwater flux rate allows placement of conventional sand cap.	Capping is not implementable within potential future maintenance dredge areas.	Numerous structures will increase the cost of cap placement. Structures no longer in use may be removed to facilitate cap placement.	Steep slopes are generally not present.	Fine-grained sediments (greater than 80% fines) are present throughout a large portion of this SDU and may require specialized cap placement techniques.	Shallow nearshore areas subject to wind and vessel generated waves will require armoring.	Capping within Swan Island Lagoon is not considered implementable due to the potential for future maintenance dredging activities. Capping may be implementable in the upper end of Swan Island Lagoon if navigation restrictions are implemented as an institutional control.

Table 10 – Dredging Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Debris/Utilities Present (Figure 9)	Water Depth (Figure 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Percent Fines (Figure 3)	Presence of Underlying Bedrock (Figure 13)	Current	Dredging Evaluation Summary
RM 1.6 – 2.8 East	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. Gasoline lines are present near RM 2.8 (near the Sauvie Island Bridge) and may preclude conventional dredging.	Water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Presence of a significant number of dock structures will limit the implementability of dredging in certain locations. Specialized dredging techniques may be required in these areas, which will likely increase the cost of dredging.	Steep sediment slopes may require special engineering considerations to limit releases and residual generation during dredging.	Percent fines are not expected to increase potential for releases during dredging.	Bedrock near the sediment surface is not specifically noted for this river reach[1].	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. Specialized dredging methods will be required beneath structures/near utilities. Presence of debris, utilities, and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls. Steep slopes may require increased engineering during dredging. The presence of the gasoline pipelines near RM 2.8 may require specialized dredging equipment or application of other technologies.
RM 3.2 – 4.1 East	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. Buried utilities have not been noted in the area.	Water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Standard dredging practices should be implementable and effective for most areas within the Sediment Decision Unit (SDU). Specialized dredging or other remediation techniques (e.g., capping) may be required in specific locations.	Steep sediment slopes may require special engineering considerations to limit releases and residual generation during dredging.	Percent fines are not expected to increase potential for releases during dredging.	Bedrock near the sediment surface is not specifically noted for this river reach[1].	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. Specialized dredging methods will be required beneath structures. Presence of debris and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls. Steep slopes may require increased engineering during dredging.

Table 10 – Dredging Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Debris/Utilities Present (Figure 9)	Water Depth (Figure 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Percent Fines (Figure 3)	Presence of Underlying Bedrock (Figure 13)	Current	Dredging Evaluation Summary
RM 4.2 – 5.0 East	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. Buried utilities have not been noted in the area.	Water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Presence of a significant number of dock structures will limit the implementability of dredging in certain locations. Specialized dredging techniques may be required in these areas, which will likely increase cost of dredging.	Steep sediment slopes may require special engineering considerations to limit releases and residual generation during dredging.	Percent fines in some areas may require containment during dredging.	Bedrock near the sediment surface is not specifically noted for this river reach[1].	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. Specialized dredging methods will be required beneath structures. Presence of debris and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls, which may be needed due to the large percentage of fines. Steep slopes may require increased engineering during dredging.
RM 6.0 – 7.0 East	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. A sewer line is present near RM 7 and may preclude conventional dredging.	Shallow water depths in this SDU may require special barge/ dredge access, but water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Standard dredging practices should be implementable and effective for most areas within the SDU. Specialized dredging or other remediation techniques (e.g., capping) may be required in specific locations.	Steep sediment slopes are not expected in this reach.	Percent fines are not expected to increase potential for releases during dredging.	Localized areas of exposed bedrock may occur. Specialized dredging/ containment techniques may be required.	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. Specialized dredging methods will be required beneath structures, near utilities, to reach shallow water areas, or when bedrock is encountered. Presence of debris and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls. The presence of the sewer line at RM 7 may require specialized dredging equipment or application of other technologies.

Table 10 – Dredging Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Debris/Utilities Present (Figure 9)	Water Depth (Figure 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Percent Fines (Figure 3)	Presence of Underlying Bedrock (Figure 13)	Current	Dredging Evaluation Summary
RM 10.6 – 11.6 East	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. Buried utilities have not been noted in the area.	Water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Standard dredging practices should be implementable and effective for most areas within the SDU. Specialized dredging or other remediation techniques (e.g., capping) may be required in specific locations.	Steep sediment slopes may require special engineering considerations to limit releases and residual generation during dredging.	Percent fines are not expected to increase potential for releases during dredging.	Bedrock near the sediment surface is not specifically noted for this river reach[1].	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. Specialized dredging methods will be required beneath structures. Presence of debris and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls. Steep slopes may require increased engineering during dredging.
RM 5.6 – 6.5 West	Principal threat waste present (non-aqueous phase liquid [NAPL])	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. Buried utilities have not been noted in the area.	Shallow water depths in this SDU may require special barge/dredge access, but water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Presence of a significant number of dock structures will limit the implementability of dredging in certain locations. Specialized dredging techniques may be required in these areas, which will likely increase the cost of dredging.	Steep sediment slopes may require special engineering considerations to limit releases and residual generation during dredging.	Percent fines are not expected to increase potential for releases during dredging.	Localized areas of exposed bedrock may occur, "particularly on the west side of the river near the St. Johns Bridge."[1]. Specialized dredging/ containment techniques may be required.	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. The presence of principal threat waste/NAPL may require the use of specialized dredging equipment (e.g., closed bucket mechanical dredging) and the use of more robust water quality controls (e.g., sheet pile wall containment).

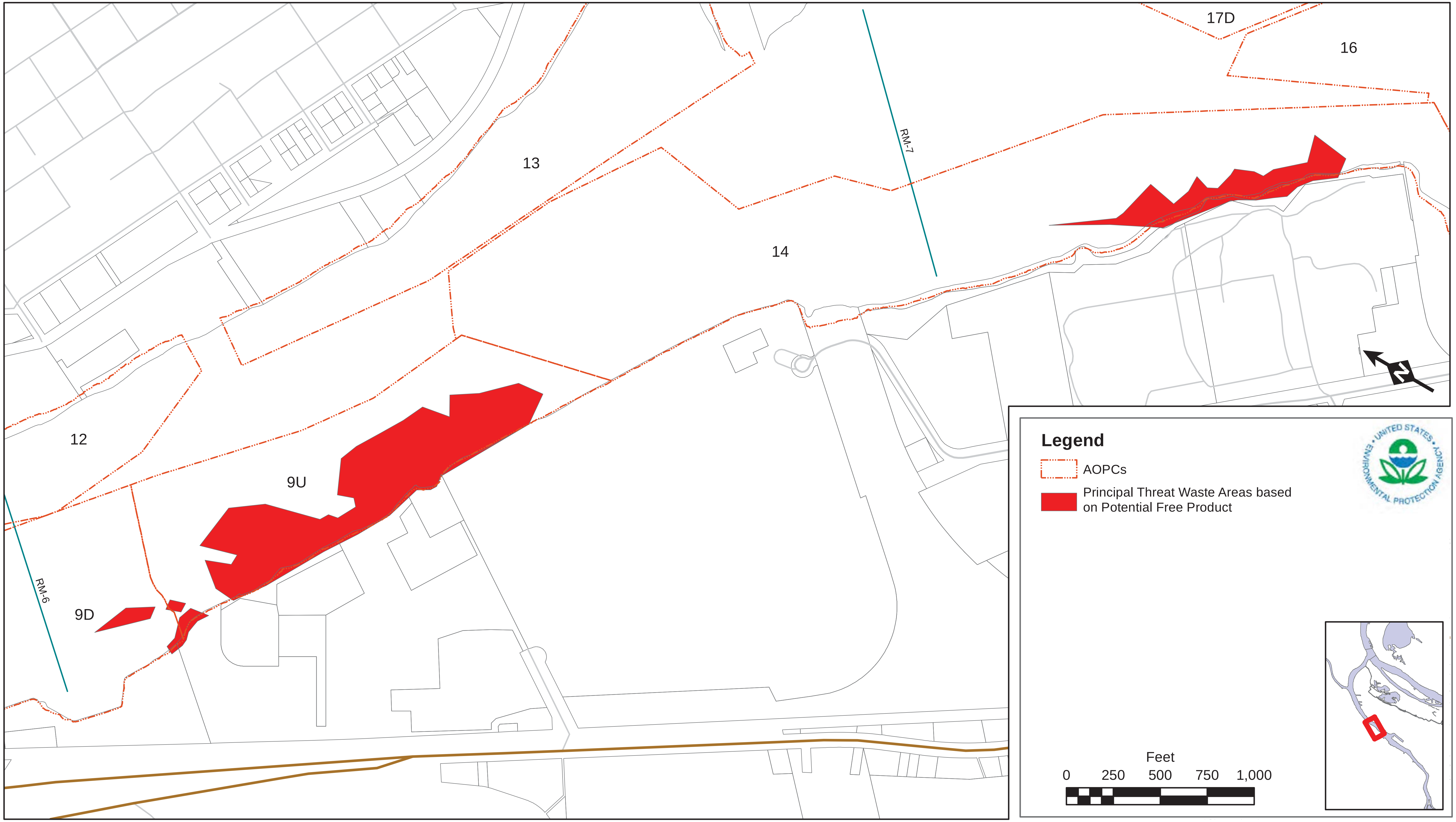
Sediment Decision Unit	Principal Threat Waste (Figure 1)	Debris/Utilities Present (Figure 9)	Water Depth (Figure 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Percent Fines (Figure 3)	Presence of Underlying Bedrock (Figure 13)	Current	Dredging Evaluation Summary
RM 6.6 – 7.9 West	Principal threat waste present (NAPL).	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. A sewer line is present near RM 7 and a petroleum pipeline has been noted near RM 7.7. These may preclude conventional dredging.	Shallow water depths in this SDU may require special barge/dredge access, but water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Standard dredging practices should be implementable and effective for most areas within the SDU. Specialized dredging or other remediation techniques (e.g., capping) may be required in specific locations.	Steep sediment slopes may require special engineering considerations to limit releases and residual generation during dredging.	Percent fines in some areas may requirement containment during dredging.	Localized areas of exposed bedrock may occur. Specialized dredging/ containment techniques may be required.	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. The presence of principal threat waste/NAPL may require the use of specialized dredging equipment (e.g., closed bucket mechanical dredging) and the use of more robust water quality controls (e.g., sheet pile wall containment). The presence of the petroleum pipeline at RM 7.7 may require specialized dredging equipment application of other technologies.
RM 8.3 – 9.7 West	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. A sewer line is present near RM 10 and may preclude conventional dredging.	Shallow water depths this SDU may require special barge/dredge access, but water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Presence of a significant number of dock structures will limit the implementability of dredging in certain locations. Specialized dredging techniques may be required in these areas, which will likely increase the cost of dredging.	Steep sediment slopes are not expected in this reach.	Percent fines may requirement containment during dredging.	Bedrock near the sediment surface is not specifically noted for this river reach[1].	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. Specialized dredging methods will be required beneath structures/near utilities or in areas of shallow water. Presence of debris and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls, which may be needed due to the large percentage of fines. The presence of the sewer line at RM 10 may require specialized dredging equipment or application of other technologies.

Table 10 – Dredging Evaluation Summary
Portland Harbor Superfund Site
Portland, Oregon

Sediment Decision Unit	Principal Threat Waste (Figure 1)	Debris/Utilities Present (Figure 9)	Water Depth (Figure 11)	Presence of Structures (Figure 8)	Sediment Bed Slope (Figure 13)	Sediment Percent Fines (Figure 3)	Presence of Underlying Bedrock (Figure 13)	Current	Dredging Evaluation Summary
RM 5.1 – 6.7 Navigation Channel	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. A sewer line is present near RM 7 and may preclude conventional dredging.	Water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Standard dredging practices should be implementable and effective for most areas within the SDU. Specialized dredging or other remediation techniques (e.g., capping) may be required in specific locations.	Steep sediment slopes may require special engineering considerations to limit releases and residual generation during dredging.	Percent fines are not expected to increase potential for releases during dredging.	Localized areas of exposed bedrock may occur, "particularly on the west side of the river near the St. Johns Bridge."[1]. Specialized dredging/ containment techniques may be required.	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered the most viable technology in this reach. Presence of debris and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls. Steep slopes may require increased engineering during dredging. The presence of the sewer line at RM 7 may require specialized dredging equipment or application of other technologies.
RM 8.1 – 8.9 Swan Island Lagoon	No principal threat waste present.	Presence of debris may require removal prior to dredging and/or increase the potential for releases during dredging activities. A petroleum pipeline has been noted near RM 7.7 and may preclude conventional dredging.	Water depth is not expected to limit dredging implementability or effectiveness. Water depth may limit effectiveness of silt curtain controls in deeper reaches.	Presence of a significant number of dock structures will limit the implementability of dredging in certain locations. Specialized dredging techniques may be required in these areas, which will likely increase the cost of dredging.	Steep sediment slopes are not expected in this reach.	Percent fines may requirement containment during dredging.	Bedrock near the sediment surface is not specifically noted for this river reach[1].	Currents are generally low and are not expected to affect silt curtain water quality controls nor increase the potential for releases during dredging.	Dredging is considered a viable technology in this reach. Presence of debris and water depth may increase the potential for releases during dredging and limit the effectiveness of silt curtain controls in deeper reaches. The presence of the petroleum pipeline at RM 7.7 may require specialized dredging equipment or application of other technologies.

Notes:
1: Integral, et al. 2011. *Portland Harbor RI/FS Draft Final Remedial Investigation Report*. August 29, 2011

Figures



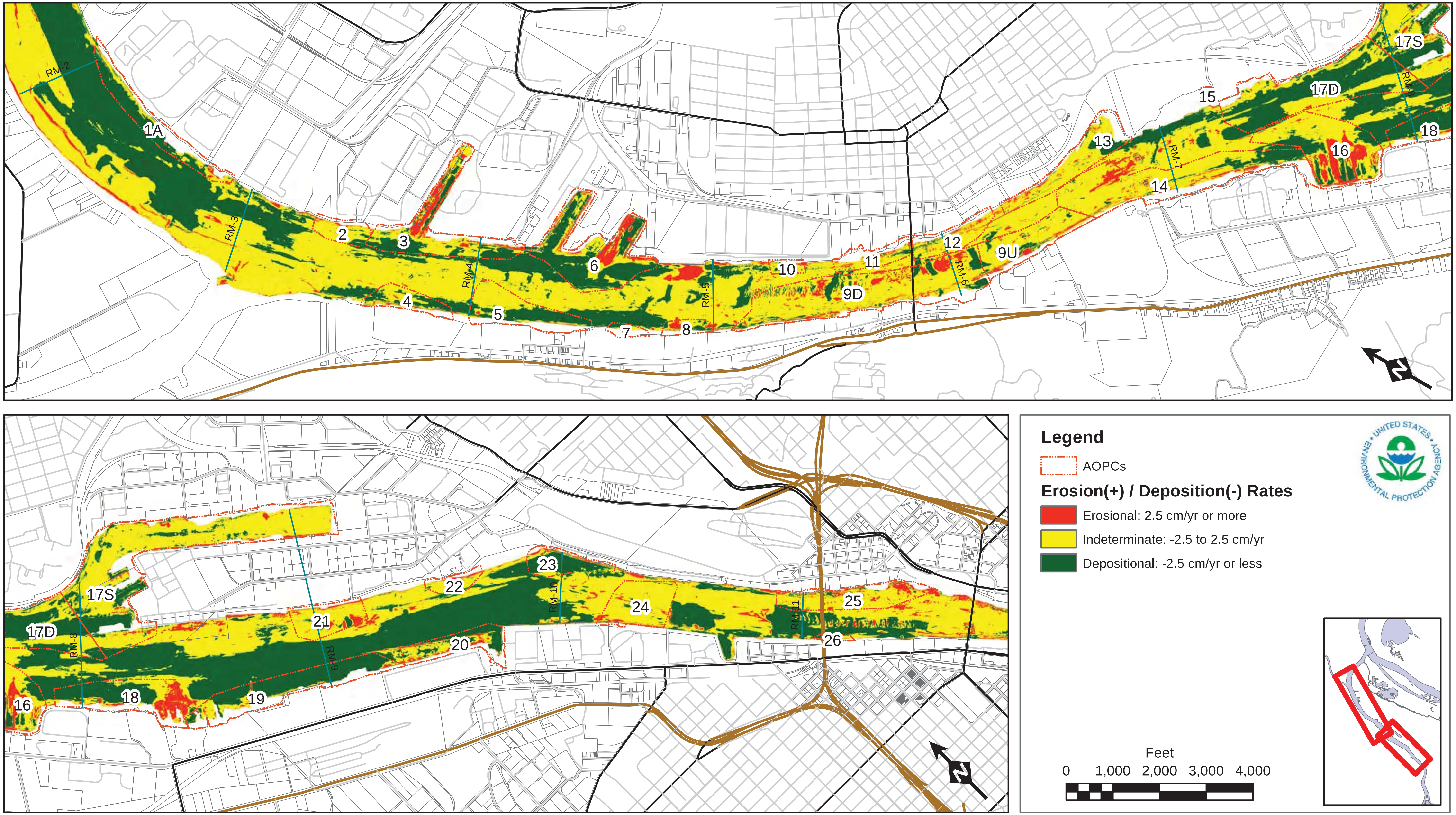
Principal Threat Waste (Potential Free Product)

Figure 1
Portland Harbor Site
Portland, Oregon

Source: GASCO and Arkema early actions areas expanded by CDM Smith interpretation of potential free product area

Path: C:\PROJECT_DATA\PortlandHarbor\Figure1_PincipalThreatWaste.mxd

Date: 7/29/2013 User: schultztm



Sediment Deposition Rates

Figure 2
Portland Harbor Site
Portland, Oregon

Path: C:\PROJECT_DATA\PortlandHarbor\Figure2_SedimentDeposition.mxd

Date: 7/29/2013 User: schultztm

Surface Sediment Texture

Figure 3
Portland Harbor Site
Portland, Oregon

Source: LWG Provided GIS Layer

Path: C:\PROJECT_DATA\PortlandHarbor\Figure3_SurfaceSedimentTexture.mxd

Date: 7/29/2013 User: schultztm

To Be Developed

Figure 4

Surface Sediment/Subsurface Sediment Contaminant Concentrations Ratio

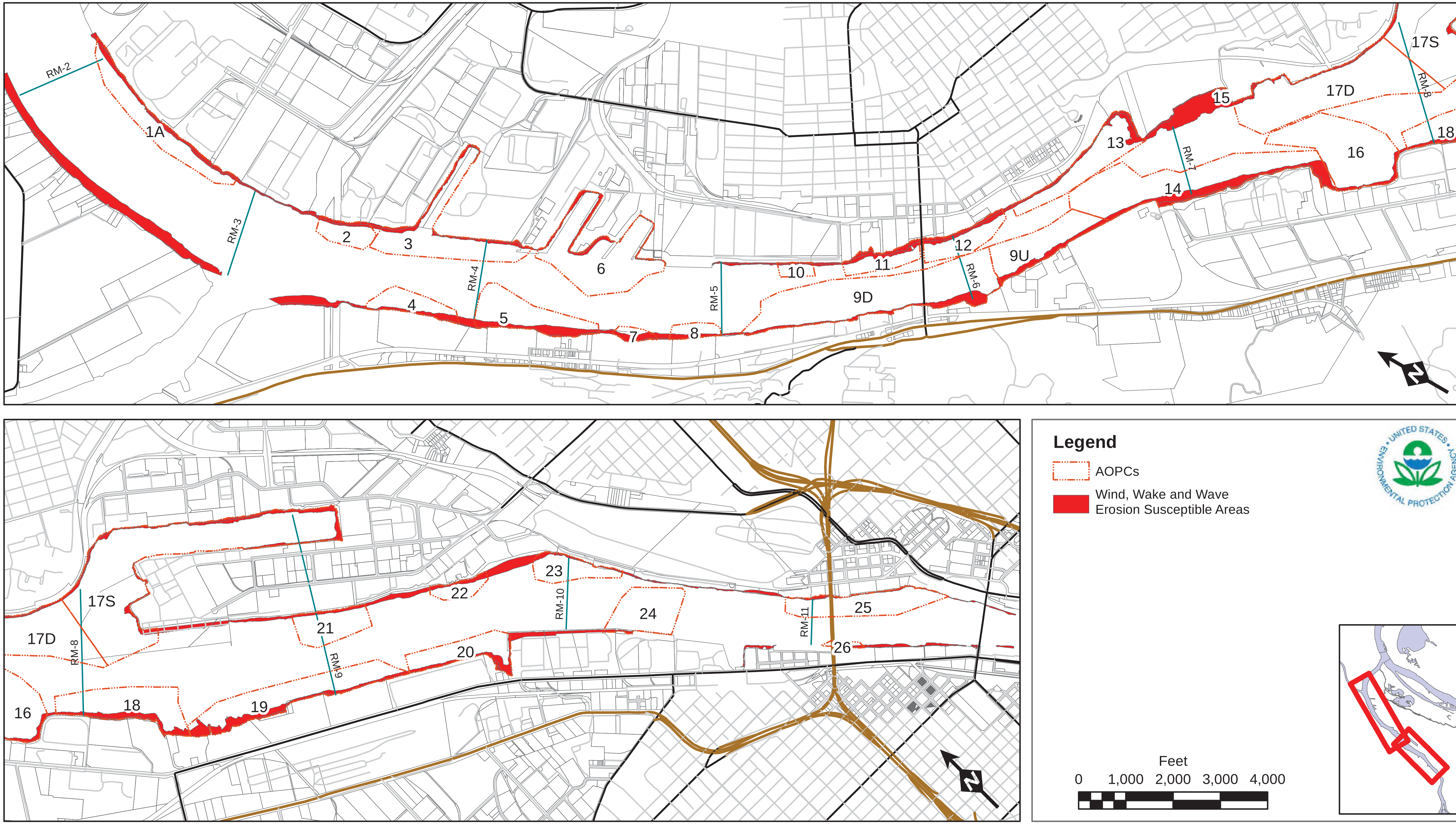
Future Potential Dredge Areas and Navigation Channel

Figure 5
Portland Harbor Site
Portland, Oregon

Source: LWG Provided GIS Layers

Path: C:\PROJECT_DATA\PortlandHarbor\Figure5_NavChannelDredge.mxd

Date: 7/29/2013 User: schultztm



Wind, Wake and Wave Erosion Susceptible Areas

Figure 6
Portland Harbor Site
Portland, Oregon

Path: C:\PROJECT_DATA\PortlandHarbor\Figure6_WindWakeWaveErosion.mxd

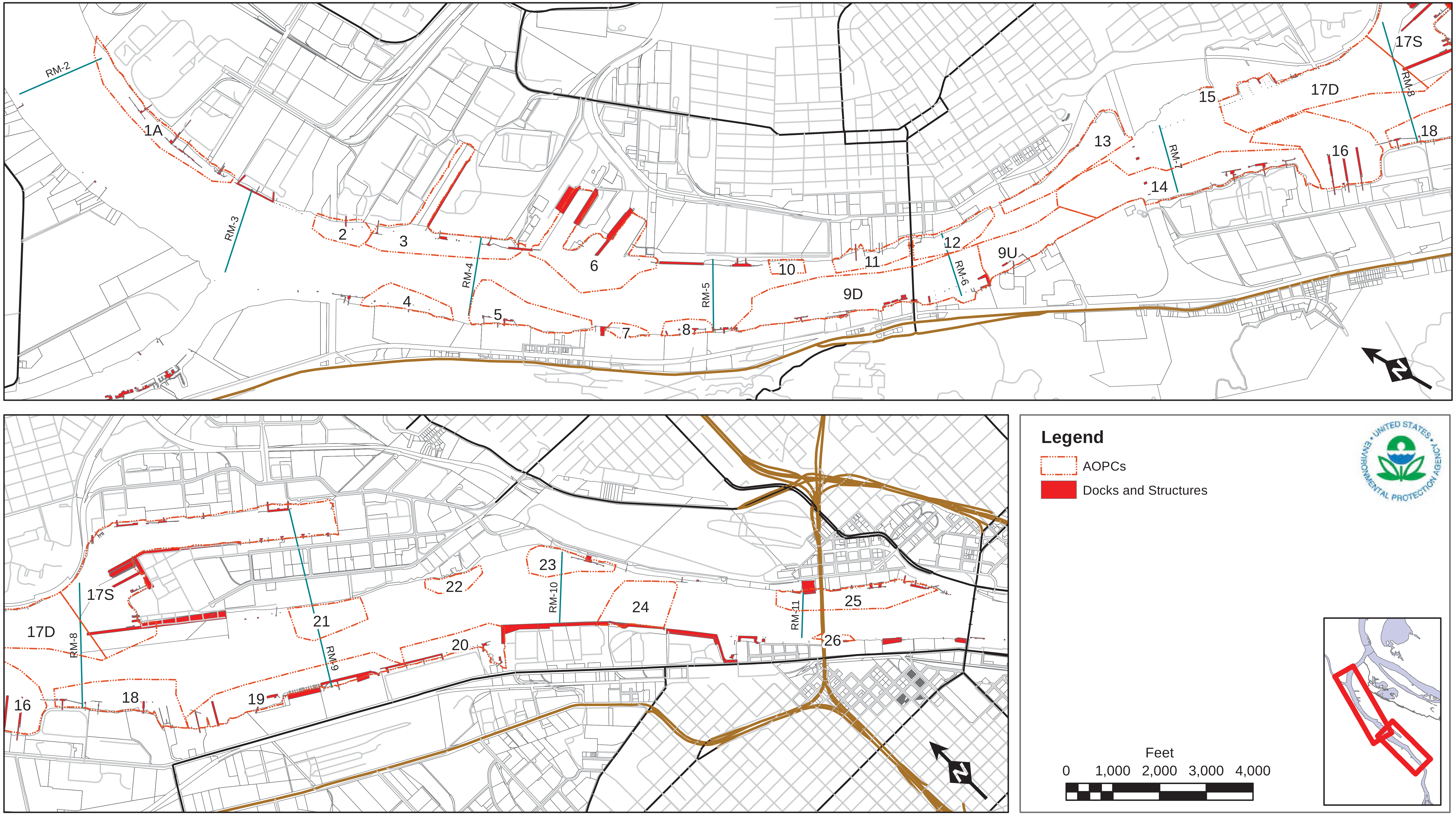
Source: LWG Provided GIS Layer

Date: 7/29/2013 User: schultztm

To Be Developed

Figure 7

In-Situ Treatment Threshold



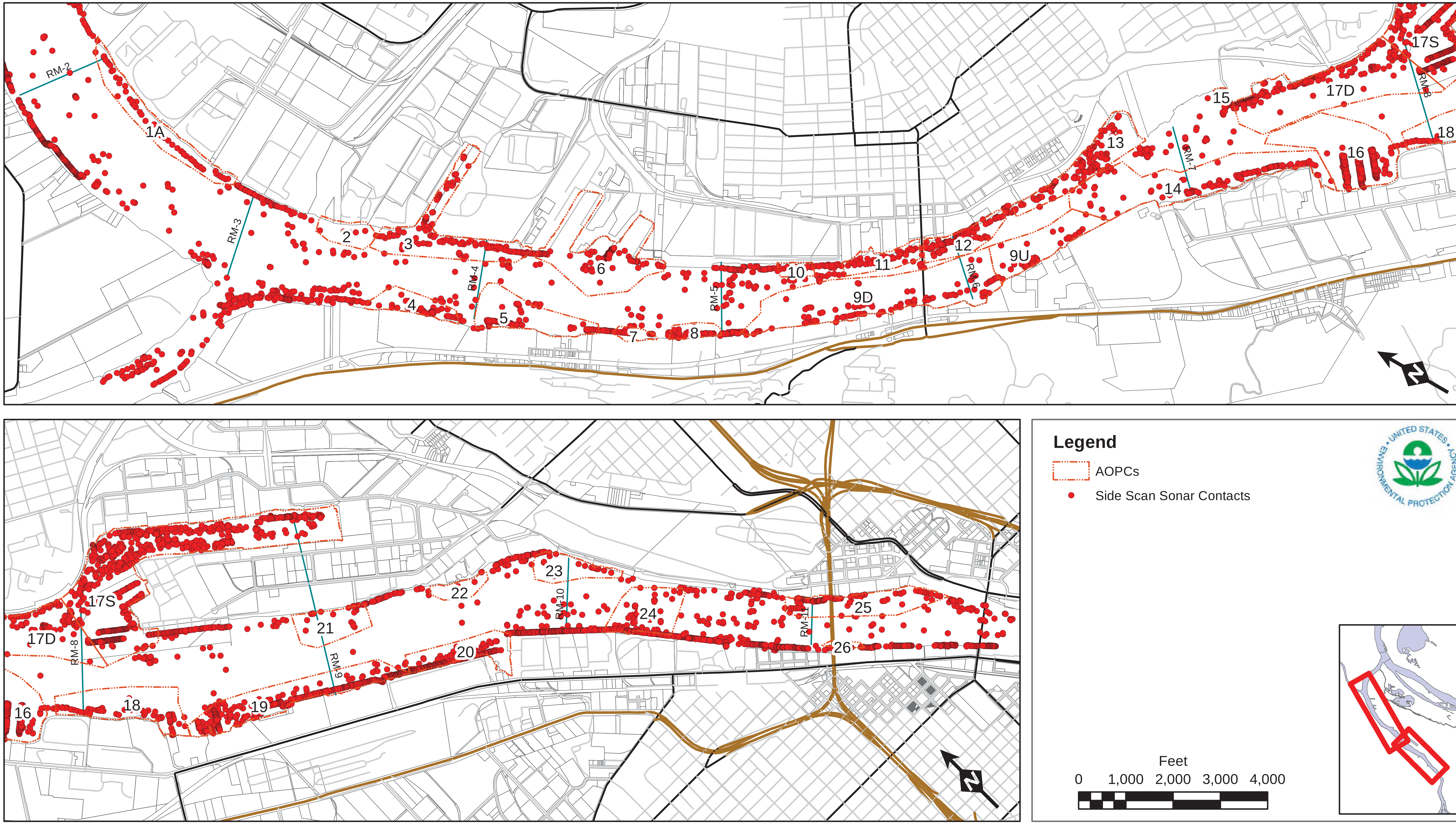
Docks and Structures

Figure 8
Portland Harbor Site
Portland, Oregon

Source: LWG Provided GIS Layer

Path: C:\PROJECT_DATA\PortlandHarbor\Figure8_DocksStructures.mxd

Date: 7/29/2013 User: schultztm



Debris and Pilings

Figure 9
Portland Harbor Site
Portland, Oregon

Source: LWG Provided Google Earth Layer

Path: C:\PROJECT_DATA\PortlandHarbor\Figure9_DebrisPilings.mxd

Date: 7/29/2013 User: schultztm

Current-induced Shear Stress

Figure 10
Portland Harbor Site
Portland, Oregon

Source: LWG Provided GIS Layer

Path: C:\PROJECT_DATA\PortlandHarbor\Figure10_CurrentInducedShearStress.mxd

Date: 7/29/2013 User: schultztm

Potential Propwash Areas

Figure 11
Portland Harbor Site
Portland, Oregon

Source: LWG Provided Bathymetry Layer

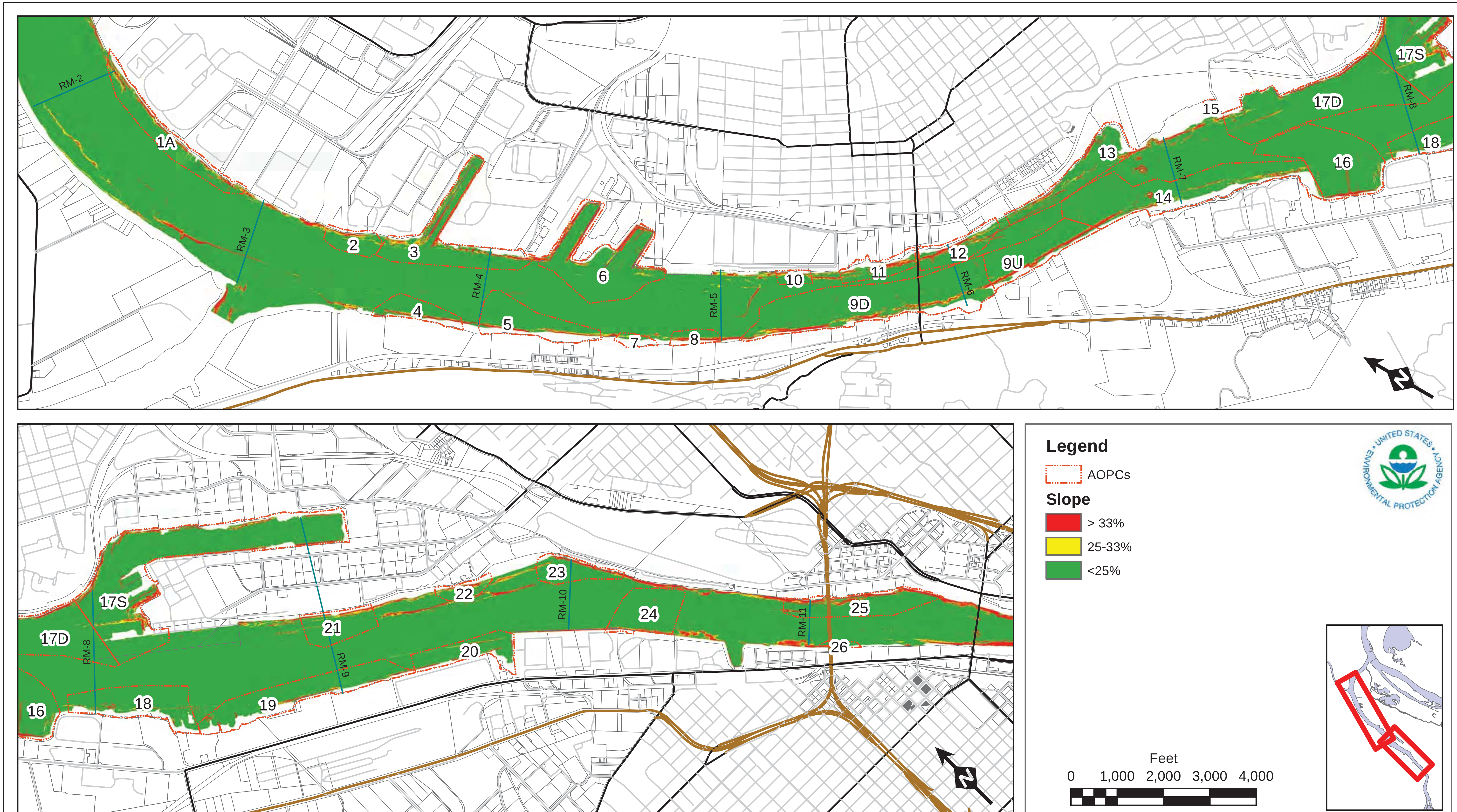
Path: C:\PROJECT_DATA\PortlandHarbor\Figure13_PotentialPropwash.mxd

Date: 7/29/2013 User: schultztm

To Be Developed

Figure 12

Significant Habitat Areas/Restoration Areas



High Sediment Slope Areas

(potentially submerged bedrock, hardpan, bridge footings, dredged and naturally occurring steep sediment slopes)

Figure 13
Portland Harbor Site
Portland, Oregon

Source: LWG Provided Bathymetry Layer with GIS slope determination

Path: C:\PROJECT_DATA\PortlandHarbor\Figure14_HighSedimentSlopeAreas.mxd

Date: 7/29/2013 User: schultztm

To Be Developed

Figure 14

Sediment Decision Units

Attachment A

Memorandum Working Draft

To: *Chip Humphrey, USEPA Region 10*
Kristine Koch, USEPA Region 10

From: *Susan Penoyar*
Eric Blischke

Date: *July 25, 2013*

Subject: *Identification of Principal Threat Waste and Hot Spots of Contamination at the Portland Harbor Superfund Site*

This technical memorandum was developed in support of the Portland Harbor Feasibility Study (FS). This memorandum presents an approach for identifying Principal Threat Waste (PTW) and Hot Spots of Contamination (Hot Spots) consistent with Federal and State requirements. The identification of PTW or Hot Spots affects the development and evaluation of remedial action alternatives in the Portland Harbor FS.

Regulatory Basis

Principal Threat Waste

The National Contingency Plan (NCP) establishes an expectation that treatment should be used to address the principal threats posed by a site whenever practicable and to use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable.

Hot Spots of Contamination

The NCP requires remedial actions to comply with all applicable or relevant and appropriate federal environmental or promulgated state environmental or facility siting laws, unless such standards are waived. The Oregon Department of Environmental Quality (ODEQ) has identified its Hazardous Substance Remedial Action Rules as an applicable or relevant and appropriate requirement (ARAR) for the Portland Harbor site. The Hazardous Substance Remedial Action Rules require identification of Hot Spots and application of the higher threshold for evaluating the reasonableness of the cost of treatment and of the cost of excavation and offsite disposal of Hot Spots in the FS.

Regulatory Definitions

Principal Threat Material

EPA's *Guide to Principal Threat and Low Level Threat Wastes* (USEPA 1991) explains considerations for categorizing waste for which treatment or containment (in the case of low level threat wastes) will generally be suitable. The PTW guidance defines PTW as source materials considered to be highly toxic or highly mobile that cannot generally be reliably contained or would provide a significant risk to human health or the environment should exposure occur. Low level wastes are defined as non-mobile contaminated source material of low to moderate toxicity.

Source Material

Contaminated sediments must first be classified as source material in order to be PTW. The PTW guidance defines source materials as materials that contain hazardous substances and act as a vehicle for contaminant transport or an exposure source. As an example, sediments contaminated with persistent bioaccumulative toxins (PBTs) such as polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDT) could be a source of contamination to fish and shellfish. Contaminated sediments could also migrate due to current or wave action. As a result, contaminated sediments should be considered source material and, in fact, are specified as such in the PTW guidance.

Concentration Based Threshold

The PTW guidance states that where toxicity and mobility of source material combine to pose a human health risk of 10^{-3} or greater, generally treatment alternatives should be evaluated. A concentration-based threshold can be determined in the following fashion: based on a sediment Preliminary Remediation Goal (PRG) for PCBs of 0.4 milligram per kilogram (mg/kg; 10^{-6} risk level, 142 grams per day, mixed diet, fillet only), a concentration-based sediment threshold of 400 mg/kg can be estimated for a 10^{-3} risk level.

Non-Aqueous Phase Liquids (NAPL)

The PTW guidance specifically identifies NAPL floating on groundwater, pooled under groundwater, or located in fractured bedrock as PTW. The proposed plan for the Lower Duwamish Waterway (LDW) implements such guidance. The LDW plan notes that PTW is defined in EPA guidance as source material that is highly toxic or highly mobile, such as pools of NAPL, and that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur.

Reliably Containable

The evaluation of whether contamination is reliably containable will be conducted as part of the FS. Material that cannot be reliably contained will be managed through removal or other remedial approaches. The evaluation of whether contamination can be reliably contained will be part of the long-term protectiveness and permanence evaluation criteria in the FS.

Hot Spots of Contamination
ODEQ Hazardous Substance Remedial Action Rules provide a specific regulatory definition for Hot Spots (OAR 340-122-0115 (32)). For media other than groundwater or surface water (e.g., contaminated sediments), Hot Spots are defined as contaminated material in which the hazardous substances:

A. Are present in concentrations exceeding risk-based concentrations corresponding to:

    i. 100 times the acceptable risk level for human exposure to each individual carcinogen;

    ii. 10 times the acceptable risk level for human exposure to each individual non-carcinogen; or

    iii. 10 times the acceptable risk level for exposure of individual ecological receptors or populations of ecological receptors to each individual hazardous substance.

B. Are reasonably likely to migrate to such an extent that Hot Spots would be created; or,

C. Are not reliably containable, as determined in the FS.

High Concentration
For PCBs, the current non-cancer risk threshold developed for the Portland Harbor site is 0.11 mg/kg. Ten times the non-cancer risk threshold is 1.1 mg/kg, which is below the PCB anthropogenic background for the Portland Harbor site. A strict interpretation of the Hot Spot definition in ODEQ Hazardous Substance Remedial Action Rules results in the entire Portland Harbor site being designated as a Hot Spot. As a result, a higher cost threshold should be applied to the evaluation of the reasonableness of the cost of treatment of contaminated sediments through in-situ treatment and application of caps containing reactive materials as well as the cost of excavation and either ex-situ treatment or offsite disposal at an authorized disposal facility.

Highly Mobile or Not Reliably Containable
Under ODEQ Hazardous Substance Remedial Action Rules, material identified as a potential Hot Spot is subject to an evaluation of whether that material is highly mobile or not reliably containable in the draft FS. The evaluation of whether sediment contamination can be reliably contained will be performed during the evaluation of capping alternatives in the FS. Sediment caps that rely on the use of activated carbon, organoclay, or other reactive materials are considered consistent with meeting the ODEQ Hot Spot treatment requirement.

Recommended Approach

Principal Threat Waste

A multiple lines of evidence evaluation to determine the presence of PTW should incorporate the following criteria:

1. Observance of NAPL contamination in Portland Harbor sediments.
2. Sediment contaminant concentrations greater than the corresponding theoretical solubility limits of the contaminant in porewater.
3. An evaluation of whether sediment contamination can be reliably contained.

Observance of NAPL

NAPL has been observed in contaminated sediments offshore of the Gasco facility. Figure 2.5.3-1 of the *Draft Engineering Evaluation/Cost Analysis (EE/CA), Gasco Sediments Cleanup Action* (Anchor QEA 2012) and Figure 1 of the *Gasco – U.S. Moorings Area Substantial Product Evaluation* (CDM Smith 2012) depict sediment cores where "substantial product" was identified. Substantial product was identified based on visual observations and using the definition of substantial product described in the Gasco Sediments Site 2009 Administrative Settlement Agreement and Order on Consent (AOC). These figures are included in this memo as **Figures 1** and **2**, respectively.

CDM Smith also evaluated whether NAPL was present in sediment cores collected offshore of the Arkema facility (CDM Smith 2013). Sediment core logs were reviewed to determine whether visual observations of blebs, globules, dark brown oily material, or other terms indicating presence of product in a quantity greater than what could be characterized as sheen are present. Other lines of evidence evaluated included sheens and odors along with corresponding elevated organic vapor meter (OVM) readings, transition zone water (TZW) and in-river groundwater concentrations exceeding 1% solubility, and the documented presence of dense non-aqueous phase liquid (DNAPL) in upland soils. Lines of evidence were evaluated consistent with criteria presented in *DNAPL Site Evaluation* (Cohen & Mercer 1993). Based on this review, CDM Smith identified the presence of NAPL in 7 sediment borings located offshore of the Arkema facility. A figure summarizing the results of this evaluation is included as **Figure 3** of this memo.

Estimated Sediment Concentrations

Sediment contaminant concentrations that would exceed the contaminant's corresponding theoretical solubility limits in porewater based on pure phase solubility were estimated for key site contaminants. These contaminants include: benzo(a)pyrene, naphthalene, total DDT, total dichlorodiphenyldichloroethylene (DDE), total dichlorodiphenyldichloroethane (DDD), chlorobenzene, trichloroethene and a range of PCB homolog groups. Saturated sediment concentrations (Csat) were estimated based on procedures outlined in a Technical Support Document developed by the Michigan Department of Environmental Quality (MDEQ 2007). Csat was estimated based on the following equation:

$$Csat = S/\rho b[(kd \times \rho b) + \theta w]$$

Where:

$Csat$ = Soil saturation concentration
S = Chemical specific solubility
ρb = Bulk density
kd = Soil-water distribution coefficient where $Kd = Koc \times foc$
koc = Chemical-specific organic carbon water partition coefficient
foc = Fraction of organic carbon in sediment
θw = Water filled porosity

The evaluation determined sediment concentrations exceeding theoretical solubility limits are present at the Portland Harbor site for benzo(a)pyrene, naphthalene, chlorobenzene and total DDT. In addition, the evaluation determined that areas of free product sediment contamination are generally limited to sediment contamination offshore of the Gasco and Arkema facilities with two exceptions. These exceptions are a surface sediment sample collected in the navigation channel downstream from the Gasco site and a subsurface sediment sample collected at Port of Portland Terminal 4. These results provide supporting evidence of the presence of NAPL offshore of the Gasco and Arkema facilities. A summary of this evaluation is presented in **Table 1**.

Reliably Containable

The evaluation of whether sediment contamination can be reliably contained will be performed during the evaluation of capping alternatives in the FS. Containment-based capping remedies in areas where PTW is present based on either Criteria 1 or 2 above will likely require the use of organoclay applied as a mat or in bulk, or a similar material as a treatment layer in the sediment cap design. Contaminated sediment containing PTW that is reliably contained using organoclay or a similar material as a reactive amendment is considered consistent with meeting the NCP requirement to treat principal threats.

Hot Spots of Contamination

ODEQ has indicated that when following a strict interpretation of their Hazardous Substance Remedial Action Rules, the entire Portland Harbor site is considered a Hot Spot and thus subject to application of the higher cost threshold for evaluating the reasonableness of the cost of treatment and removal and offsite disposal. Evaluation of whether sediment contamination is highly mobile or not reliably containable will be evaluated in the draft FS in a manner similar to the PTW reliably containable evaluation.

Conclusions

Based on the presence of NAPL and elevated sediment concentrations, PTW appears to be present in sediments offshore of the Gasco and Arkema facilities. Other areas of the site have sediment contamination exceeding a 10^{-3} cancer risk level. However, sediment PRGs corresponding to a 10^{-3} cancer risk level are generally too low to be useful for identifying PTW at the Portland Harbor site due to the widespread areas of sediment contamination exceeding the 10^{-3} cancer risk threshold.

Strict application of the ODEQ Hot Spot requirement results in the entire Portland Harbor site being identified as a Hot Spot. Contingent on the State of Oregon further clarifying its interpretation of ODEQ's Hot Spot identification requirement or pursuing a waiver of this requirement based on technical impracticability, a higher cost threshold should be applied for the removal and/or treatment of contaminated sediments at the Portland Harbor site consistent with ODEQ requirements and generally accepted evaluation procedures.

References

Anchor QEA. 2012. *Draft Environmental Engineering/Cost Analysis, Gasco Sediments Cleanup Action.* Prepared for U.S. Environmental Protection Agency, Region 10 on behalf of NW Natural. May 2012.

CDM Smith. 2012. *Memorandum re: Gasco – U.S. Moorings Area Substantial Product Evaluation.* Prepared for U.S. Environmental Protection Agency, Region 10. October 26, 2012.

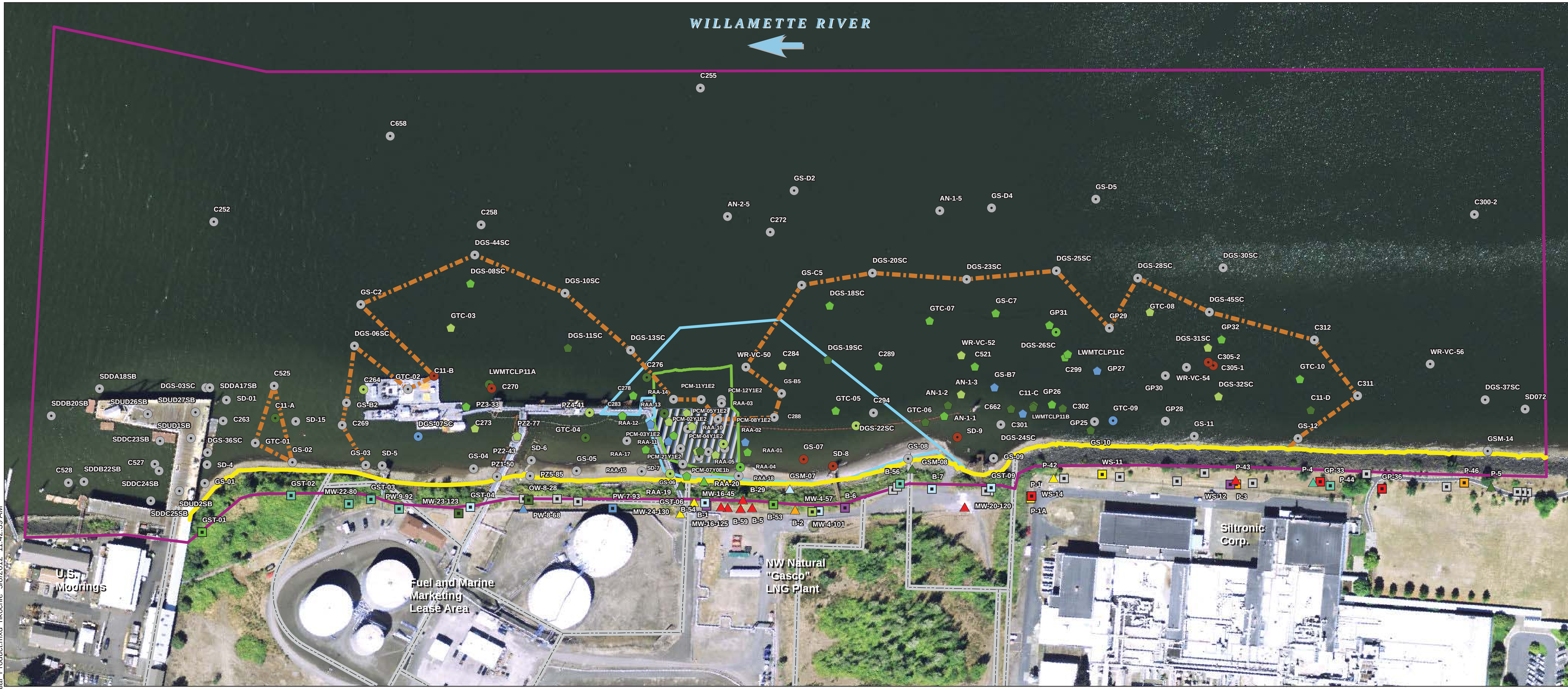
CDM Smith. 2013. *Memorandum re: Arkema Offshore NAPL Evaluation.* Prepared for U.S. Environmental Protection Agency, Region 10. June 25, 2013.

Cohen, R.M., and J.W. Mercer. 1993. *DNAPL Site Evaluation*. C.K. Smoley and CRC Press, Boca Raton, Florida.

Michigan DEQ, 2007. *RRD Operational Memorandum No. 1, Technical Support Document – Attachment 8.* May 2007 with June 27, 2007 correction.

U.S. Environmental Protection Agency (USEPA). 1991. *Guide to Principal Threat and Low Level Threat Wastes.* Superfund Publication 9380.3-06FS. November 1991.

Figures



- Sediment Coring Location
- Core with Liquid Substantial Product
- Shoreline Soil Boring Location
- Boring with Potential Mobile Product
- Inconclusive Substantial Product
- No Substantial Product
- Substantial Product from 0-4 feet Below Mudline
- Substantial Product from 4-8 feet Below Mudline
- Substantial Product from 8-12 feet Below Mudline
- Substantial Product from 12-16 feet Below Mudline
- Substantial Product from 16-20 feet Below Mudline
- Substantial Product from 20-24 feet Below Mudline
- Substantial Product from 24-28 feet Below Mudline
- Substantial Product from 28-32 feet Below Mudline
- Substantial Product from 32-36 feet Below Mudline
- Substantial Product >36 feet Below Mudline
- Gasco Sediment Site Area of Interest (Final Work Plan [Anchor QEA 2009])
- Substantial Product Area
- Tar Body Removal Action 6-inch Fringe Cover Placement
- Tar Body Removal Action Area (RAPP [Anchor 2005])
- Tar Body Removal Action Pilot Cap
- Boundary of EPA Managed Sediments and DEQ Managed Uplands – 13 feet NAVD88

NOTES:
1. Arrow indicates direction of flow of river.
2. Horizontal datum is NAD83 HARN Oregon State Plane North, Intl. Feet.
3. Vertical datum is NAVD88.
4. Aerial imagery from July 2007.
5. Review of the core logs at the locations designated as Inconclusive Substantial Product provided insufficient information to confirm the presence of substantial product using the definition in the Statement of Work (e.g., stained sediments noted in an interval but no thickness provided).
6. The designated depths of substantial product are the deepest depth of substantial product observed in the core/boring log. Shallower depths may not contain substantial product.
7. Locations designated as containing liquid substantial product contain liquid substantial product in at least one depth interval. These locations may also contain non-liquid substantial product and the shown deepest depth interval designation may be driven by either liquid substantial or non-liquid substantial product.
8. Per the SOW, the definition of substantial product does not apply landward of the top of the riverbank. The shown top of riverbank borings were screened against the SOW substantial product definition solely to support evaluation of substantial product in the riverbank.

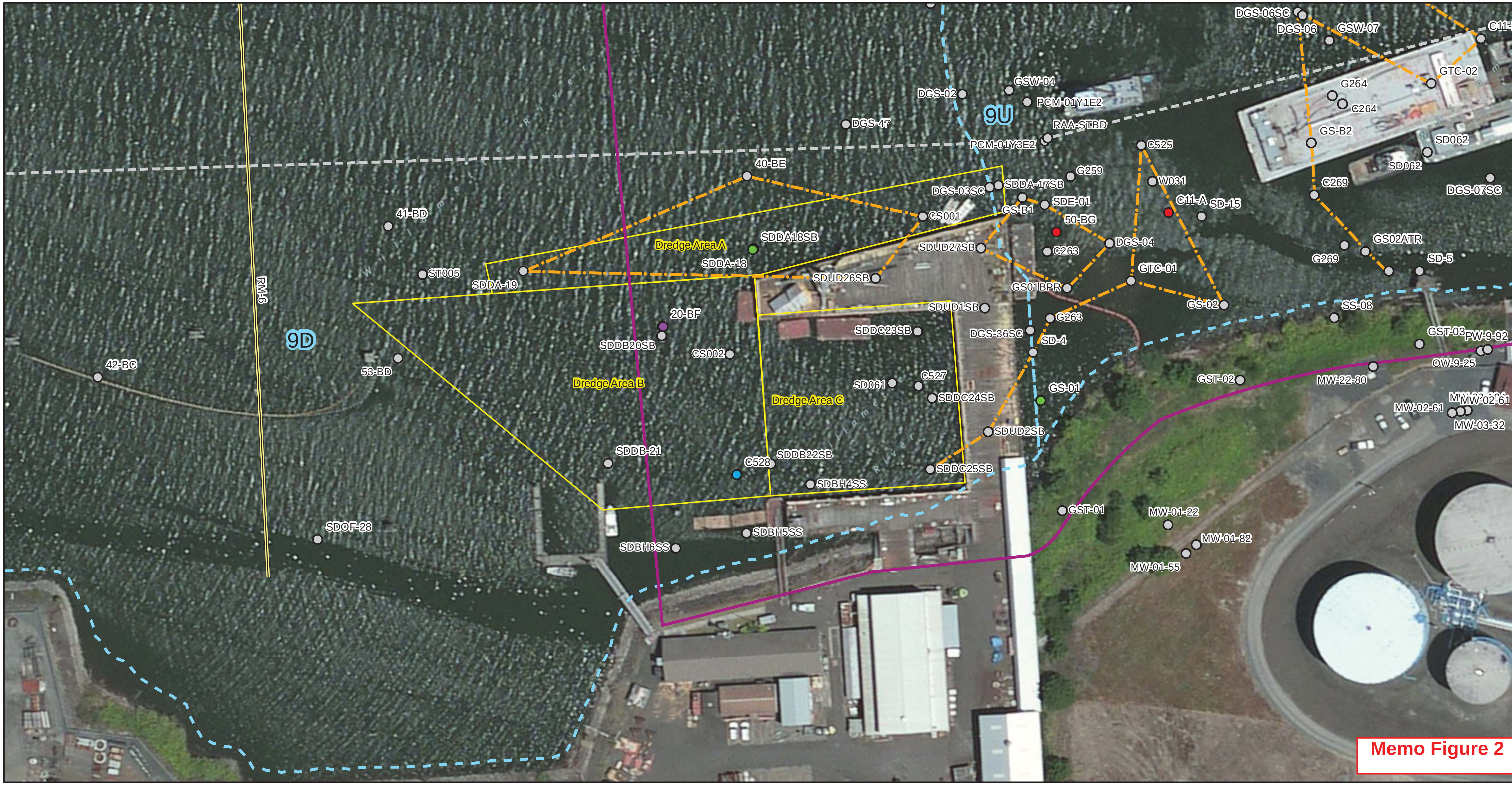
Memo Figure 1

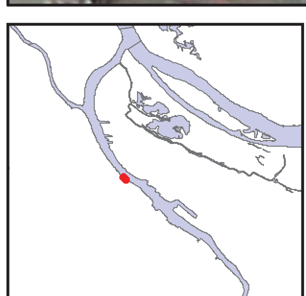
Q:\Jobs\000029-02_Gasco\Maps\EECA\EECA_Substantial_Product.mxd nkochie 5/8/2012 11:42:39 AM

ANCHOR QEA

Feet
0 100 200 300 400

Figure 2.5.3-1
Summary of Presence of Substantial Product
Draft Engineering Evaluation/Cost Analysis
Gasco Sediments Cleanup Action





Legend

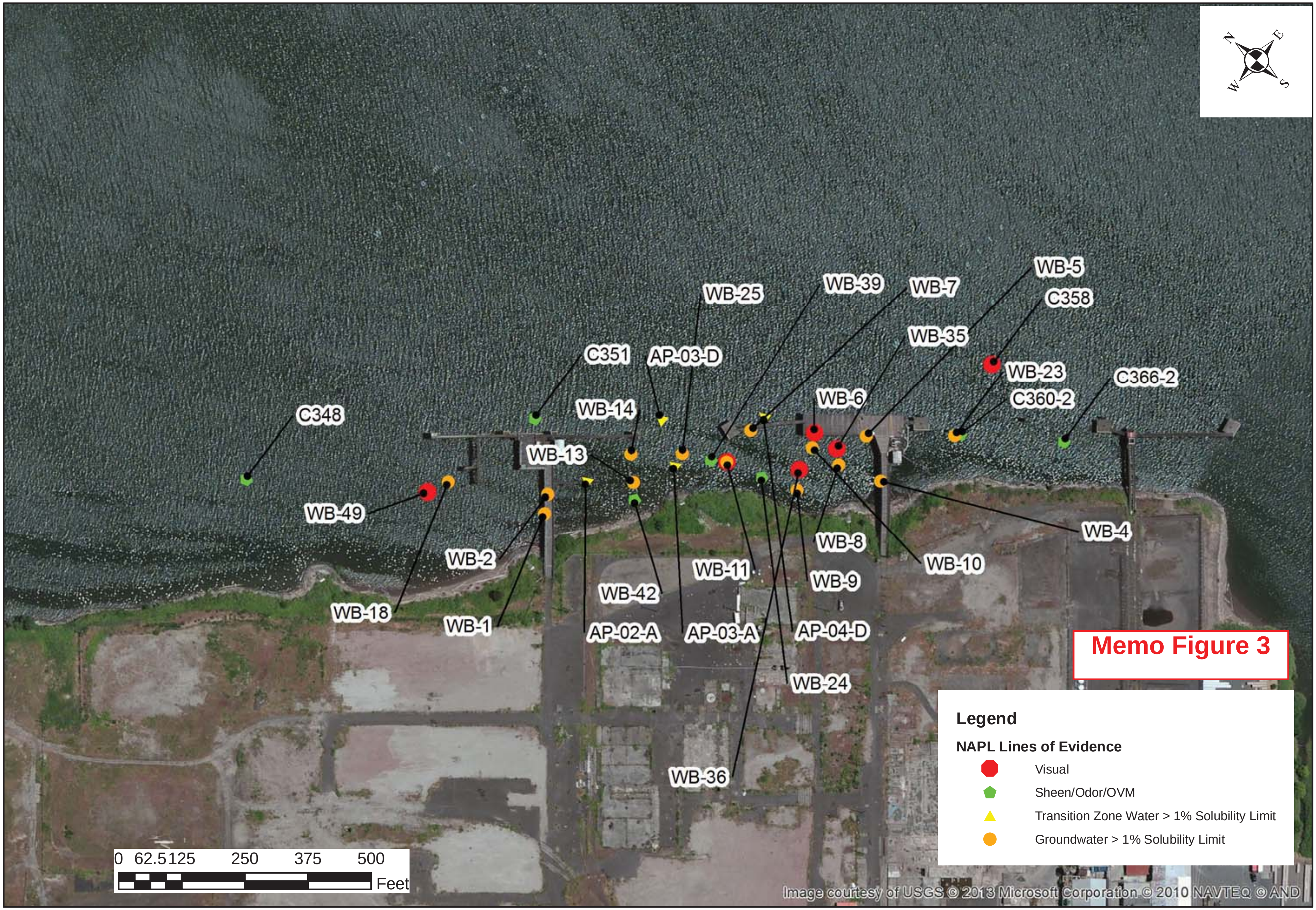
- Substanial Product Boundary
- Gasco Sediments Site Area of Interest
- U.S. Moorings Maintenance Dredge Areas
- AOPC Boundary
- Navigation Channel
- River Miles
- No Substantial Product
- Non-Aqueous Phase Liquid (NAPL)
- Substantial product from 0-5 feet below mudline
- Substantial product within 5 ft of new surface material
- Substantial product may be within 5 ft of new surface material (unclear from log)

Figure 1
Summary of Presence of Substantial Product
U.S. Moorings Offshore Area
Gasco Sediments Site Area of Interest

100 50 0 100
Feet

Date: 10/17/2012

Figure 1: Non-Aqueous Phase Liquid (NAPL) Evaluation
Arkema Inc.
Portland, Oregon



Table

Table 1 – Estimated Saturated Sediment Concentrations
Portland Harbor Superfund Site
Portland, Oregon

Chemical	C(sat)	Notes
Benzo(a)pyrene	250 mg/kg	Widespread exceedances offshore of Gasco and Siltronic. One exceedance in navigation channel downstream of the St. Johns Bridge and one exceedance at Terminal 4, Slip 1.
Naphthalene	600 mg/kg	Widespread exceedances offshore of Gasco and Siltronic.
Trichloroethene	2,600 mg/kg	No exceedances; maximum concentration offshore of Siltronic at 1,900 mg/kg.
Chlorobenzene	3,500 mg/kg	One exceedance offshore of Arkema between docks.
Total DDT (sum of 2,4 and 4,4'- DDT)	76 mg/kg	Numerous detections offshore of Arkema between docks.
Total DDD (sum of 2,4 and 4,4'- DDD)	270 mg/kg	No exceedances; maximum detection is 77 mg/kg offshore of Arkema.
Total DDE (sum of 2,4 and 4,4'- DDE)	36 mg/kg	No exceedances; maximum detection is 2.8 mg/kg offshore of Gunderson.
Trichlorobiphenyls	400 mg/kg	No exceedances; maximum detection is 12.7 mg/kg offshore of Gunderson.
Tetrachlorobiphenyls	790 mg/kg	No exceedances; maximum concentration is 14.2 mg/kg offshore of Gunderson.
Pentachlorobiphenyls	1,600 mg/kg	No exceedances; maximum concentration is 4.62 mg/kg offshore of Gunderson.
Hexachlorobiphenyls	13,000 mg/kg	No exceedances; maximum concentration is 2.99 mg/kg offshore of Gunderson.
Heptachlorobphenyls	8,000 mg/kg	No exceedances; maximum concentration is 2.8 mg/kg offshore of Willamette Cove.

Note: Occurrences of sediment concentrations exceeding theoretical solubility limits are highlighted in Table 1.
mg/kg – milligrams per kilogram　　DDT - dichlorodiphenyltrichloroethane
DDD – dichlorodiphenyldichloroethane　　DDE - dichlorodiphenyldichloroethylene